SPECIAL REPORT: AIR TRAVEL SECURITY

AIR&SPACE

Smithsonian

JANUARY 2002

Up Front

THE VIEW INSIDE FAMOUS COCKPITS

Spirit of St. Louis

FLY BY FLAPPING

PAGE 36

powers of 10
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ETIENNE DE MALGLAIVE

Not least among the grave injuries the world suffered on September 11 was the desecration of airliners. On that day, every advancement ever made in aviation—every piece of precision engineering, every tweak in performance and safety, all the worldwide, decades-long efforts made to improve air travel—was repudiated by the intent to destroy.

Will we ever look at airplanes in the same way again? Will those of us who always looked up when we heard an airplane overhead, just for the pleasure of watching it for a few moments, still be able do that without flashing back on the gruesome images of that day?

Today aviation's future seems uncertain, but for comfort we need only look at its history: a hundred years of great struggle and almost incomprehensible progress. We don't believe the momentum has changed.

—The editors

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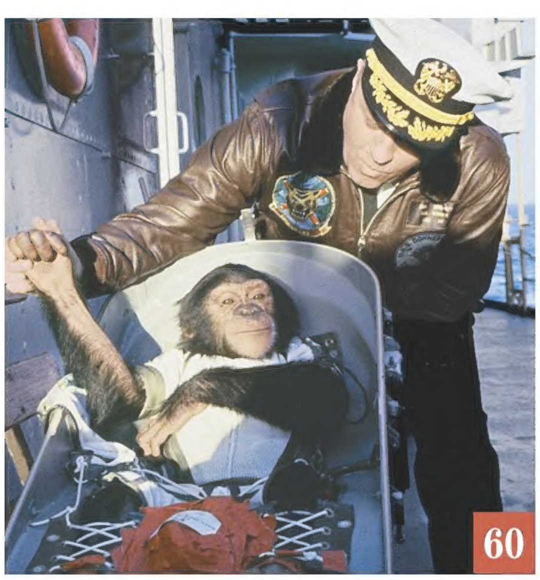
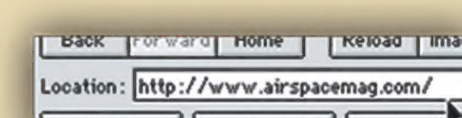
FEATURES



Cover: *The wicker chair (bottom), the multiple fuel tank valves (center), the famous periscope: Lindbergh's spartan furnishings gleam in a photograph by Eric Long and Mark Avino.*

DEPARTMENTS

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A Matter of Scale

People often spend their first moments in the National Air and Space Museum looking up. Above them hang such aviation treasures as the 1903 Wright *Flyer* and Charles Lindbergh's *Spirit of St. Louis*. These machines dazzle visitors because they're the real thing—the actual airplanes that made history. But as visitors explore the rest of the Museum, they find a trove of smaller treasures: the exquisitely crafted model aircraft that help to explain in a more intimate way the history and technology of aviation.

The National Air and Space Museum's aircraft collection is the largest and finest in the world, but without models we could not tell the whole story of aviation. Model aircraft have played a significant role in our exhibits since Secretary Samuel P. Langley helped the Smithsonian become the nation's foremost repository of aviation artifacts. Paul E. Garber joined the Smithsonian as an exhibit creator. One of his first assignments was to build replicas of World War I military aircraft, and by the eve of World War II, he had built or collected hundreds of models.

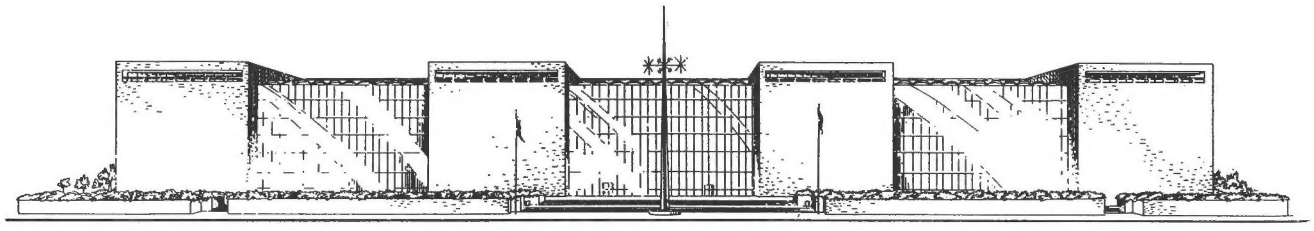
In the 1930s, aeromodeling flourished. Educators and the military encouraged the activity to introduce aircraft designs and future pilots to the world of aviation. At Smithsonian-sponsored model aircraft contests, Paul Garber served as chief judge, and he persuaded several winners to donate their models to the Museum.

During World War II, Garber accepted a Navy commission and worked closely with the Navy's Bureau of Aeronautics in two programs to produce recognition models for the U.S. military. In one, high school students carved wooden models using templates and materials that Garber ensured were accurate. In the other, the Cruver Company of Chicago used injection molding to mass-produce models. By the time the program ended in 1961, more than a million models had been produced. Afterward, the models became collector's items, sparking a brisk trade well into the 1960s. One of the largest collections is on display in the World War II Aviation Gallery.

After the war, Congress authorized a National Air Museum to house the Smithsonian's collection, bolstered by scores of military aircraft, U.S. and foreign, donated to the Museum in 1946. The Museum was finally funded in the 1970s. Garber and his colleagues had most of of the models they needed, but others remained to be built. Fortunately, exhibit model-making had been evolving toward an extraordinarily high standard. Two examples are Arlo Schroeder's 1/16-scale model of a Grumman TBF-1 Avenger torpedo bomber in the Sea-Air Operations Gallery and Steven Henniger's massive 1/100-scale model of the aircraft carrier USS *Enterprise*, complete with its contingent of aircraft.

Today the collection has grown to over 3,000 models. Many important aircraft no longer exist, some cannot be acquired, and some are too large to fit in the galleries. In fact, the majority of the collection remains in storage at the Paul E. Garber Facility in Suitland, Maryland. The opening of the Steven F. Udvar-Hazy Center at Dulles International Airport will change that, but models will continue to be critically important at both the Hazy Center and the Museum on the Mall.

—J.R. Dailey is the director of the National Air and Space Museum.



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Editorial: (202) 275-1230
e-mail: editors@airspacemag.si.edu
Web site: www.airspacemag.com

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LETTERS

Tales of the Stupid, Continued

Perhaps the ultimate "under the bridge" buzz job ("Stupid Plane Tricks," Oct./Nov. 2001) was performed in 1965 at the Douglas MacArthur Bridge over the Detroit River. The bridge joins the island of Bell Isle Park to the city of Detroit; its main arch has barely 40 feet of clearance. During an airshow, Don Pittman decided to try flying through it. That day, numerous boats were on the river, their inhabitants watching the airshow, so Pittman had even less clearance than normal. Nevertheless, he and his Pitts Special made it through.

Michigan has had its share of stupid plane tricks. In the August 9, 2001 edition of the *St. Ignace* (Michigan) *News*, there was a letter to the editor from Glenn Gustafson, a former employee of the Mackinac Bridge Authority, reporting that no less than 15 airplanes have flown under the Mackinac Bridge, which joins Michigan's Upper and Lower Peninsulas. Although this can be considered a risky stunt, pilots do have a vertical clearance of 210 feet. Even a B-47 was able to fly under it.

—Bob Pauley
Farmington Hills, Michigan

Editors' note: The pilot of the B-47, Captain John Lappo, was court-martialed for the stunt and found guilty of disobeying Air Force regulation 60-16: "Except during take-off and landing, aircraft will not be flown at less than 500 feet above the ground or water." He was allowed to stay in the Air Force but was never permitted to fly for the service again.

During the war, I trained to fly in PT-17s at Decatur, Alabama. On many days, while flying back to the airfield, my instructor buzzed the river and obviously thought of flying under the bridge near the airfield, but he always peeled up just before going under. One day, while he was giving me a ride in his car to the nearby town, we stopped on the bridge and he measured the distance from the bottom of the bridge to the water. It was six inches shorter than the airplane's height. I learned a lot from that episode.

—James Cornaire
Scotia, New York

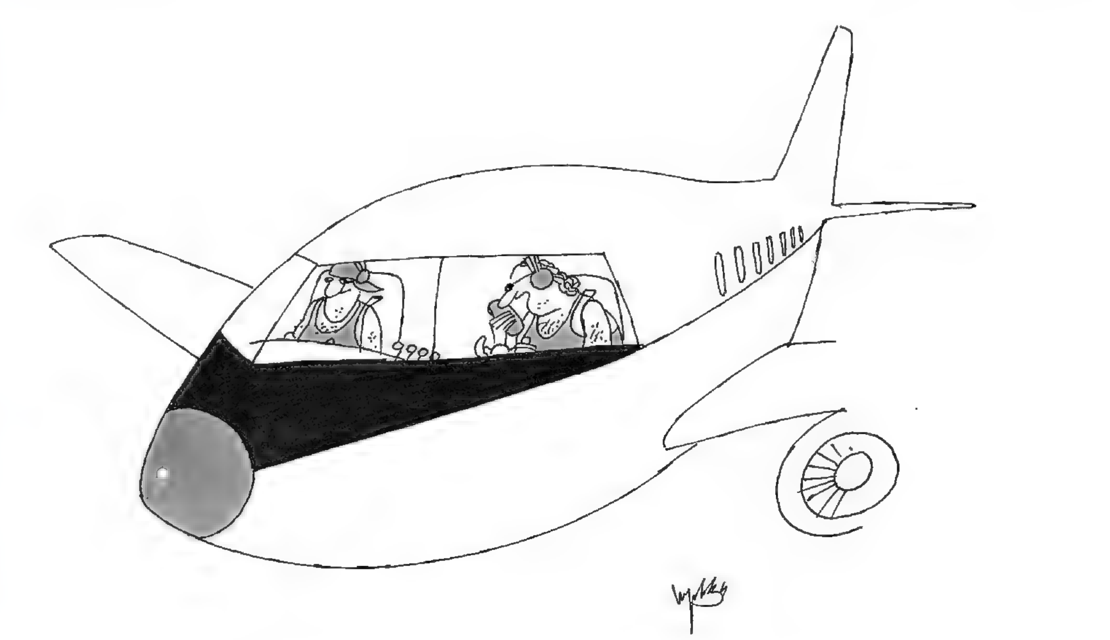
In 1942 I was an aerial navigator posted at an air base in Salinas, California. Once a week, all officers were called to the post theater for a meeting with our commanding officer, who had graduated from West Point. One of his first warnings was: "It is absolutely forbidden to fly under the Golden Gate Bridge." Of course, a bunch of us rushed off to do just that.

When my pilot and I flew under it, I suggested that since we were so low, why not do the Bay Bridge too? So we did.

—Richard H. Wright
no address provided

Phil Scott states that Lincoln Beachey drowned in San Francisco Bay in 1915 after a wing snapped off his monoplane, *Little Looper*. In fact, he was flying a replacement for *Little Looper*. Had he stayed with his original plane, the accident probably would never have happened.

—Jerry Coleman
Belmont, California



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Several years ago, I was at my parents' house, watching TV and waiting to pick my wife up from work. My father, a simple coal miner's son from West Virginia, entered the room and sat down beside me to see what I was watching. I told him it was a program about aviation, and, knowing he didn't share my interest in that subject, I just mumbled the name of the military pilot who was on.

Upon hearing my answer, my father leaned forward, squinted at the TV, and, with a look of disdain, exclaimed: "That's that durn fool that flew under the bridge in Killsite. Or was it Beckley? I think it was Killsite. What the devil are they talking to him for?"

Perhaps you folks could find out if Chuck Yeager did, in fact, fly under any bridges in West Virginia.

—Jim Beverley
Branchburg, New Jersey

Editors' reply: The General was apparently not above such low-level stunts, in West Virginia and elsewhere. A back issue of the Charleston Gazette *refers to a local "legend" that has Yeager flying an F-80 under the South Side Bridge, which spans the Kanawha River in Charleston. The story is that the flight surprised spectators of boat races being held on the Kanawha.*

We also found the following exchange in an interview with Yeager published in Senior Lifestyle *magazine:*

Q: There's quite a local legend, if you will, that says you actually flew under the old Bidwell Bar Bridge [near Oroville, California, where Yeager's Army Air Corps squadron trained]. Is that true?

Chuck: No, I never flew under the old Bidwell Bar Bridge. I did, however, fly under that big 200 feet concrete arch bridge over the river [it's no longer there]. We all did! We also used to go and fly under those big power lines out in the valley.

Phil Scott writes that pilots must stay 2,000 feet or more above most structures. The Federal Air Regulations say that to avoid obstacles, pilots must fly 1,000 feet over the highest obstacle within a horizontal radius of 2,000 feet.

—Jeff Pardo
Rockville, Maryland

It's been said that some F-4 jocks, presumably out of Nellis Air Force Base, would go blasting across the bottom of Death Valley (elevation: 282 feet below sea level) for membership in the clandestine Below Sea Level Club fraternity. Does anybody know if this was fact or fiction?

—Bill Sheppard
San Francisco, California

A few stupid plane tricks have been done on the ground. One I know of involved an offer to back up a B-17, which, of course, had no reverse-pitch propellers. After the bets were made, the pilot started up the B-17, then stepped hard on either the right or left brake pedal. Either the number 1 or number 4 engine was advanced, which backed up the opposite side of the plane. This was a bit hard on the tires, and the backward zig-zagging attracted too much unwanted attention, so it wasn't repeated much.

—Norman S. Benedict
Santa Maria, California

I was a member of the 70th Fighter Wing, Ninth Air Corps, stationed in Paris in 1944. One bright, sunny day I decided to do some sightseeing. I was standing on the lower deck of the Eiffel Tower when I saw a recon plane, perhaps an L-5, to the west. All of a sudden I saw the L-5 turn toward the tower. I watched the plane come toward me, saw it enter the west arch, and then, as I ran toward the open center of the deck, saw it flying below me. The pilot continued through the east arch and on toward the military college. The plane then gained altitude and flew away.

—Bertram E. Bogue
Tacoma, Washington

An American Seiran?

"All and Nothing" (Oct./Nov. 2001) called to mind a design for a scout plane that my father helped develop (left). Like the Aichi Seiran, it was designed to be stowed on a sub (its wings were detachable, rather than foldable). It had a monocoque fuselage made of linen and 1/8-inch gumwood. The aircraft did fly, but because the designers lost their financial backing, they never were able to develop it for military use.

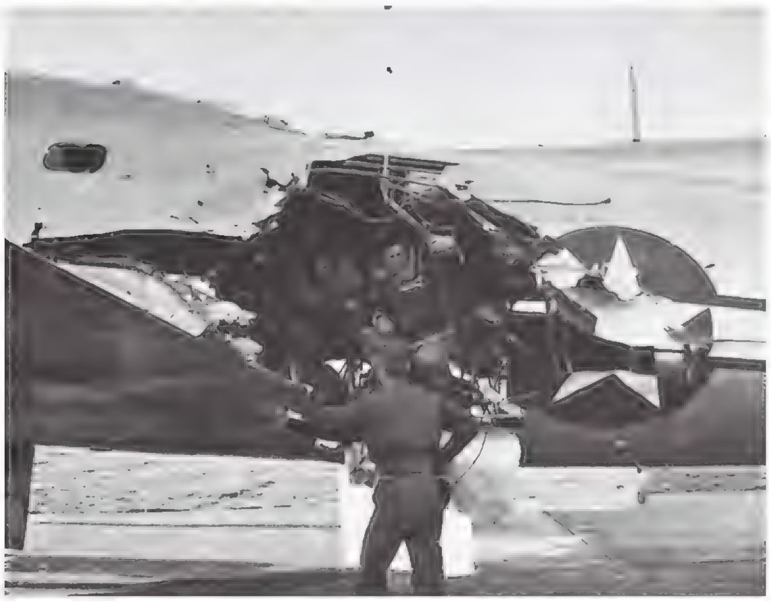
—C.W. Brix
Chicago, Illinois

Unbeatability

Here is the story behind the photograph on the upper portion of page 49 ("Unbreakable," Oct./Nov. 2001): The pilot is Major Loren Herway, commanding officer of the 377th Fighter Squadron, 362nd Fighter Group. He had been on his 124th mission, strafing the Luftwaffe airfield at Worms. During the mission his P-47's turbocharger section was hit by flak. He managed to nurse the plane back to his airfield at Etain, France, where he had to circle the field for 15 minutes, as his landing gear wouldn't lock in the down position and he had to give the crash crew members time to get into place. When they were ready, he bellied the plane in safely. As the crash crew started to tow the plane away, the entire tail section fell off. Herway survived the war, a good part of it due to the ruggedness of the P-47.

—Jeffrey Lucash
Chesapeake, Virginia

The enclosed photo (below) shows the lead aircraft after it returned from a November 6, 1944 mission to Harburg, Germany. I was the navigator, and just prior to bomb release, we took a direct hit. We flew home on three engines and landed at Royal Air Force Rackheath.



The aircraft stayed held together by two longerons and the keel. Boeing built them tough.

—Colonel Don Wellings
U.S. Air Force (ret.)
Friday Harbor, Washington

My dad, John H. Payne Jr., did a stint as a depot test pilot before he was sent to the Pacific. I believe he was based in Richmond, Virginia, at the time. He tells of one flight when he was test flying a recently repaired P-47D. At altitude, he was startled to see half the starboard wing break off at the flap/aileron line! He found that if he kept the plane at high speed, it would be stable, but if he reduced speed or let go of the stick (which you kinda had to do to bail out), the plane departed. So, having a controllable plane, he figured he'd try to land it.

He flew the Jug back to base and to grass-cutting height at high speed, then, at zero altitude, cut power to drop it on the ground. The plane instantly did a complete snap-roll and slammed belly-down onto the asphalt. It then careened through the dispersal area, shedding wings and empennage. Dad recalls plowing through a set of boarding stairs and under a Lockheed Constellation before his airplane stopped. He was dazed from damaging the gunsight with his forehead, and when they hauled him out, he was trying to turn off all the switches he was supposed to turn off at the end of a flight, even though they were no longer connected to anything.

A few hours later he woke up in a hospital bed. He was told that the Jug had ended its travels nosed into a railroad embankment at the edge of the field, with only the cockpit left intact. Okay, so the plane wasn't exactly unbreakable, but it got him down alive.

One of the souvenirs he brought home from the war was the top half of the stick grip from that plane.

—John Payne
Oakland, New Jersey

Supersonic Recalculations

In "The Concorde Redemption" (Aug./Sept. 2001), Joseph Harriss writes that the Concorde was designed "when engineers still used slide rules and log tables to figure out supersonic aerodynamics." I cannot speak for engineers working in the United States, but as a supersonic aerodynamicist employed at the time by the Bristol Aeroplane Company at Filton, I do not recall seeing a slide rule in the office, and log tables were principally used for obtaining the value of sines and cosines. There was, however, a large team of "computers," the term used for the group—mainly ladies—who operated the electro-mechanical machines (Facits and Fridens) and who undertook step-by-step analyses of trajectories and other things for the aerodynamicists and inverted matrices for the aeroelasticians. There was also a large analog computer known as RYP (Roll Yaw Pitch), used for real-time investigations.

Our first large digital computer, an English Electric DEUCE (Digital Electronic Universal Computing Engine) was installed and commissioned by the end of 1955, and the following year, a number of the engineering staff, particularly the supersonic aerodynamicists and aeroelasticians, started to write programs in Alpha code. Some time later we were using Algol, and I can assure Mr. Harriss that both the Supersonic Transport and the Guided Weapons and Space Divisions of what was by then Bristol Aircraft Ltd. regarded DEUCE as an extremely important design tool. It was used first on the Bloodhound Mk.2—Bristol's long-range, moving-wing surface-to-air guided weapon. We were able to settle the Bloodhound's aerodynamic shape before we undertook tests in a supersonic wind tunnel.

—Charles C. Halton
Curtin, ACT, Australia

Your article mentions that "the only takers [for the Concorde] were their two captive, state-owned national carriers." It neglects to add that by 1965, about 10 airlines, including Pan Am, TWA, American, and Continental, had taken out options on a total of 47 Concordes. By the following year, the number of interested airlines had risen to 13. Of course, options are not firm orders, but all these airlines evidently felt that supersonic travel could be a hit. Thus the assertion by National Air and Space Museum curator Ron Davies that "there was never a market for [the Concorde]" lacks credibility.

By the early 1970s, the market for a supersonic transport was looking shaky, mainly because of the introduction of large wide-bodies with lower seat/mile costs, but it was the fuel crisis of 1973 that put the nail in the SST's coffin.

I can't deny that the Concorde is a rather inefficient beast, but if rich people are willing to spend $10,000 for a round-trip transatlantic journey that takes only six and a half hours, rather than 14 or 15, who are we to stop them? As for direct financial profit, a slim one is better than a loss.

—Justin Bannah
Brisbane, Queensland, Australia

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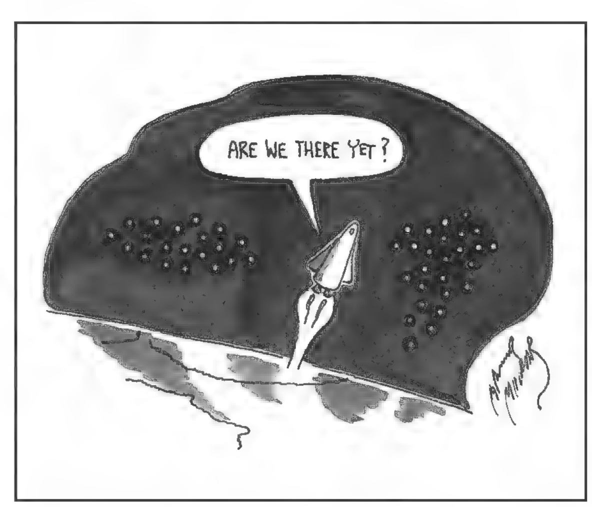


A Mission Expanded

When airliners headed toward the World Trade Center and the Pentagon last September, it was the Air National Guard that was dispatched in a desperate attempt to stop the attacks.

From Otis Air National Guard Base in Massachusetts, F-15s from the 102nd Fighter Wing descended on New York. At Langley Air Force Base in Virginia, F-16s from North Dakota's 119th Fighter Wing were scrambled to Washington. Both units were already on alert status when the call came, but as the world knows all too well, there wasn't enough time for either unit to limit the disasters.

In late September, mid-level U.S. Air Force generals were given the authority to order the destruction of any aircraft in U.S. airspace that is deemed to be a terrorist threat. Most of this heavy task falls on the citizen soldiers of the Air National Guard.

Unlike the active-duty members of the Air Force, most Guard pilots are civilians who fly part-time. Many of them are airline pilots. They may now be called upon to shoot down their colleagues.

U.S. AIR FORCE

In late September, mid-level U.S. Air Force generals were given the authority to order the destruction of any aircraft in U.S. airspace that is deemed to be a terrorist threat. Most of this heavy task falls on the citizen soldiers of the Air National Guard.

As the cold war wound down, the U.S. military downsized and reorganized. To save money, the role of continental air defense was transferred from the Air Force to the Air National Guard. The North American Aerospace Defense Command has overall responsibility, but day-to-day operations are run by the 1st Air Force Air National Guard in Tyndall, Florida. When an unannounced aircraft approaches U.S. soil, be it a Russian Bear over the North Atlantic or a doctor hurrying home from vacation in the Bahamas, it is likely to be met by combat-ready Air Guard fighters.

"Mike Bob" is the call sign for the lieutenant colonel who commands the North Dakota Air National Guard. (For security reasons, it's the only name he will reveal.) It was his F-16 pilots that dashed to Washington on the 11th. He declined to answer any questions that he thought might reveal current flight operations, but he confirms reports that the Guard's mission has been expanded to include combat air patrols over New York, Washington, and a dozen other cities. In the event of another hijacking, airborne Guard pilots will be able to respond instantly with missiles and cannon.

"We all share the horror of shooting at unarmed civilian aircraft," says Mike Bob. "It's something we never thought about until these events happened. It's the course of last resort and it's part of the national defense now. We're just trying to see that America's skies are safe."

—Tim Wright

Acronyms Readers May See (ARMS)

Anyone reading the newspaper during the early stages of the air campaign in Afghanistan was greeted with some unfamiliar acronyms for certain new precision-guided munitions (PGMs) that have recently been added to the Department of Defense inventory for those branches of the service that drop explosives from airplanes.

The Joint Direct Attack Munition (JDAM) is a $21,000 kit that modifies standard 500-, 1,000-, and 2,000-pound bombs. It consists of a set of strakes that attach to the sides of the bomb and a steerable tail fin unit that responds to signals from a GPS receiver and from an inertial guidance system to put the bomb precisely on a set of latitude-longitude coordinates. Pilots load the target coordinates before takeoff, during the mission, or by means of an optical target designator aboard the aircraft that enables the pilot to point to a target with a set of crosshairs. Built by Boeing, the JDAM, advertised to have an accuracy of approximately 40 feet, made its combat debut during Operation Allied Force in the Balkans.

Another comparatively new munition is the Joint Standoff Weapon (JSOW), a modern version of the Bat guided glide bomb of World War II (see "The Bat," p. 52).

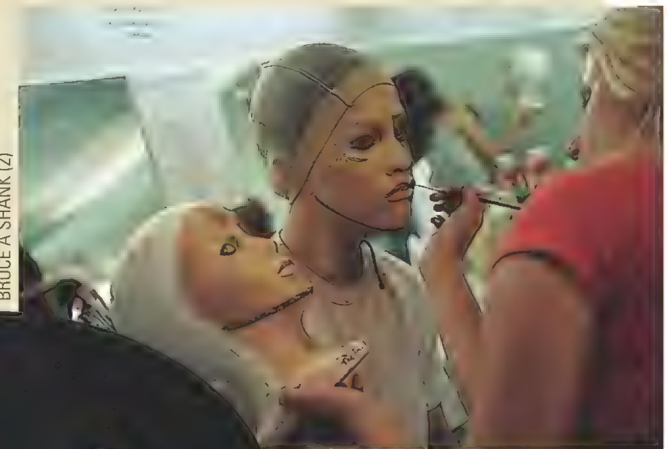
Raytheon builds the JSOW, which comes in two varieties: the A version dispenses 145 BLU-97 (Bomb Live Units) bomblets against targets like radars or trucks; the B model dispenses six BLU-108 anti-armor submunitions, which are used to attack, well, anything with armor. The JSOW has previously been employed in Iraq and Kosovo. It can use a variety of guidance systems, including GPS, and can be released as far as 40 miles from the target from high altitude.

What makes the weapons "joint" is that the Air Force, Navy, and Marine Corps can all employ them. Their precision is driving down the amount of explosives needed to take out a target, so bombs are getting smaller. The 500-pound version of the JDAM is adequate for many targets and creates less collateral damage than the larger versions. There has been some discussion of future versions as small as 100 pounds. Photographs of after-strike results indicated that precision munitions used to crater runways in Afghanistan had struck smack dab on the white centerline. (The 2,000-pound JDAM that struck a civilian area in late October had been programmed with incorrect longitude and latitude coordinates.)

—*George C. Larson*

THEATRICS

Life Imitates Art



BRUCE A SHANK (2)

Neil Armstrong got the nod to be first on the moon because of a keen engineering mind and almost superhuman stick-and-rudder skills. Thirteen-year-old Sebastian Pastaanos got the nod to portray the guy who got the nod because he was smaller than the 50-year-old investment banker who portrayed moonmate Buzz Aldrin. "Sebastian is a foot shorter than me," says David Perry, the model for Aldrin. "That goes a long way to add depth to a painting."

The "painting" appeared at the Pageant of the Masters, Laguna Beach, California's summer-long celebration of *tableaux vivants*—paintings, statues, murals, and other artworks re-created in remarkable exactitude by actors. The artworks to be portrayed are selected by pageant advisors for their relevance to the pageant's theme and the viability of portraying them on a stage. For the 2001 pageant—the 64th—organized around the theme "Beyond the Horizon," Perry and Pastaanos slid into frame to portray the astronauts of Norman Rockwell's 1969 canvas "The Final Impossibility."

To prepare, Perry and Pastaanos underwent a makeup session followed by a fitting in makeshift Apollo moonsuits. Seeing the duo up close and under the harsh fluorescent lights of the pageant's staging area gave me little confidence that Rockwell's masterpiece was about to be three-dimensionally re-created. Watching them climb into a wood, metal, and velvet lunar environment did little more to allay those fears.

But when that curtain opened and the lights came on, all I could do was say "Aahhhhh," clap, and nod with amazement like everybody else in the audience. A Marine seated nearby had an even more effusive analysis. "Holy crap," he exclaimed, "that's dead on!"

Posing at Pageant of the Masters is time-consuming (tryouts begin in January), and all the participants are volunteers and receive no salary, stipend, or flight pay. However, this year one company gave passes to all who participated. "It's really cool," said Pastaanos. "Because I'm doing this they give me a free trip to Disneyland."

—*D.C. Agle*

Bring Your Own Range

Kodiak Launch Complex—the first complete launch facility built in the United States since the 1960s and the first not owned by the federal government—is remote. On a good day, it is a 75-mile drive from its namesake town in Alaska and 41 miles from civilization, at the end of a potholed trail where FedEx Priority Overnight means second business day. Buffalo roam the parking lot.

At first glance, the Alaska Aerospace Development Corporation's $40 million facility south of Anchorage seems to have it all. Its 67-degree latitude, wide-open launch corridor, and unobstructed downrange flight path make it an ideal location for sending payloads weighing up to 8,000 pounds into low-Earth polar and sun-synchronous orbits. It has a launch control center, a satellite processing facility, a spacecraft assembly building, and a pad for launching small to medium rockets.

But what Kodiak lacks is a rocket range—weather and tracking equipment that keep ground personnel in touch with the launch vehicle. It had tested a few Army missile interceptors but never launched anything to orbit until September 29, when a Lockheed Martin Athena 1 boosted four small satellites into polar circuits. Collectively known as Kodiak Star, the payloads comprised experimental and test satellites. One, with 1,500 aluminum mirrors—which made it look suspiciously like a disco ball—would be tracked by schoolchildren around the world, who were learning the fundamentals of orbital mechanics by logging onto a Web site to follow the reflective sphere and report its path around the planet.

The $38 million mission went off without a hitch after a month of setbacks, including software glitches, mechanical problems, stormy weather, a solar flare that threatened to upset the rocket's guidance system, and even the terrorist attacks on New York and Washington. (The temporary ban on air travel kept engineers from Florida's Kennedy

Space Center—KSC manages rocket launches for all of NASA—from making a cross-country trek to Alaska for several days.)

Alaska's first orbital launch was a particular challenge for the Floridians, who were accustomed to the abundant infrastructure and manicured comfort of Cape Canaveral. "This is quite a bit of a leap for us to go to a place where there is no range capability—to bring in our own range," confesses NASA launch manager Charles Dovale, "and to learn what it's like to apply NASA's stringent range safety criteria on a mobile range in a brand-new location. The military does it more often."

In 18 months, NASA, the Air Force, and Lockheed Martin built a range from scratch. The 45th Space Wing at Patrick Air Force Base in Florida, which forecasts weather for launches at Cape Canaveral, added meteorological instruments to the launch tower and set up a portable radarscope. KSC installed lightning detectors. NASA's Wallops Flight Facility in Virginia wheeled in its unique mobile range—vans full of the telemetry and control equipment that would be needed to monitor the Athena's ascent and destroy the rocket if it veered off course.

What had been one of Alaska's most promising economic enterprises is also devoid of customers; demand for low-Earth-orbiting small satellites has virtually dried up since construction of Kodiak began. But Lockheed Martin is betting on an upswing in the market for small launch vehicles as microsat technology improves, commercial Earth-imagers become more economical to fly, and NASA's budget catches up with its appetite for low-cost scientific explorers. Lockheed Martin's Roger McNamara figures it will happen in two or three years—time enough for the Alaska Aerospace Development Corporation to build its own range.

—Beth Dickey

NASA

Roll Your Own

Thousands of homebuilt enthusiasts are happy to cut and bend, grind and weld, and glue and screw together the various pieces of an airplane, but most of them wouldn't dream of tackling that thundering lump of metal in the nose—the engine. Putting together one of those is for people in white shopcoats whose wrists are calibrated in foot-pounds and fingertips can feel a bearing clearance in thousandths of an inch. Besides, what if you make a mistake and the engine ralphs its valves out the exhaust pipe?

Engine manufacturer Superior Air Parts hopes to change that attitude. Superior has just introduced the 180-horsepower, four-cylinder SL360 aircraft engine, and some assembly is required. Make that all assembly is required: the SL360 arrives on your porch as a box of parts, and it's up to you to put it together. Only once before has such a concept been tried. In the 1970s, Teledyne Continental offered a do-it-yourself version of its little O-200 four-cylinder, but the price was so high that fewer than 10 kits were sold.

The $16,990 price of the Superior engine doesn't include the accessories such as the magnetos, carburetor, starter, and other necessities (another $3,200 buys that box), but it does include tuition for a day's attendance at the Build & Technical School of engine overhauler Mattituck Services, in the tiny town of Mattituck on eastern Long Island. (Superior also plans

COMING ATTRACTIONS

Chrome by Chrysler

It takes me two big steps to climb up behind the big steering wheel of a 1938 Dodge Airflow aviation fuel tanker. Barry Dressel, manager of the Walter P. Chrysler Museum in Auburn Hills, Michigan, calls this the "signature vehicle" of his operation, which celebrates the American heritage of today's merged German-American automaker, DaimlerChrysler.

The landmark design echoes that of the 1934 Chrysler and DeSoto Airflow cars. "Streamlined, fuel-efficient, fast, comfortable, and competitively priced, they were unfortunately regarded as ugly by a public attuned to long hoods, sweeping fenders and grinning grilles," Walter J. Boyne wrote of the Airflow in his 1988 book *Power Behind the Wheel*, equating the sales flop with that of Ford's Edsel 20 years later.

The design proved more appealing to oil companies and breweries. About 270 such tankers were built to order from 1935 to 1940. Only a dozen survive, and Dressel thinks Chrysler's is the only running example. The Dodge was acquired, in rough condition but complete, from a South Carolina collector, who said it had worked at Chicago's Midway airport. Retired Chrysler engineer Michael Krag supervised the restoration, based on extensive research in corporate archives of the truck, to running condition. Access to Chrysler's parts bins and shops helped, especially when the cast iron centerpiece of the front bumper proved irreparable and a new casting had to be made and plated. Museum restoration specialist Bill Ridenour rebuilt the grille: 22 chrome strips and 98 fasteners.

KEVIN A. WILSON (2)

Ridenour climbs up into the passenger seat next to me, and, imagining I'm assigned to refuel an Eastern Airlines DC-3, I select second gear (first was for a full load of fuel) and set off. The unassisted steering is heavy and acceleration is leisurely, but I worked the beast up to 35 mph, wishing for full tanks to smooth the ride.

Too big to fit in the 75-car museum building, the Airflow is displayed at car shows and in parades, and Dressel says he might welcome an invitation to an airshow or vintage-aircraft gathering. Call the museum at (888) 456-1924 or visit www.chryslerheritage.com

—Kevin A. Wilson

to establish engine building classes in Florida and California.) Mattituck will also provide a builder with follow-up hand-holding by phone.

Can you learn to assemble a four-cylinder engine in just a day? An air-cooled, single-cam, overhead-valve flat-four like an SL360 (a copy of the classic Lycoming O-360 with numerous upgrades and improvements) is basically a great big Volkswagen engine, and thousands of hippies tore into those things in the '60s after reading dog-eared copies of the late John Muir's Bug bible, *How To Keep Your Volkswagen Alive*. An acquaintance who gives three-day classes in how to build a Porsche 911 engine—and three days makes sense, since a flat-six Porsche engine is considerably more complex than an aircraft four-cylinder—once told me, "I can teach anybody with a pulse how to build that engine."

Build your own SL360 and you'll save about $3,000 over the ready-to-run version, Superior's XP-360. "That may or may not be worth it to you," admits Superior vice president Tim Archer, "but the other part of it is the educational side. We're trying to keep in the spirit of the EAA [Experimental Aircraft Association], which is all about teaching people about aeronautics, about flying, about how to build an airplane. We want to carry it one step further, to the engine."

—*Stephan Wilkinson*

WORKS IN PROGRESS

LEWIS E. WHITE

A Lockheed P-38 that sat for decades under 268 feet of ice in Greenland and was extracted in 1992 (see "Iced Lightning," Dec. 1992/Jan. 1993) is prepped for a comeback in Middlesboro, Kentucky, where a meticulous restoration is ongoing. *Glacier Girl* is in the hands of The Lost Squadron P-38 Museum, which hires restoration experts and supervises their work. "Every piece of the plane was damaged in some way or another," says project manager Bob Cardin. "We were able to save most of it but had to fabricate 20 percent from scratch." Cardin estimates the cost of the restoration at $2.4 million—not counting the $638,000 spent "cold-mining" it in Greenland. When completed, the airplane will fly at airshows, and in the off-season will star as the museum's main attraction.

BAR BETS

What Concrete Shortage?

With all the talk about the shortage of airports and runways being the major cause of airspace congestion, it should be pointed out that some cities have a lot of runways—for instance, Houston, which, counting private facilities and heliports, has 18 landing facilities (Clover Field, David Wayne Hooks Memorial, Ellington Field, Flyin' B, George Bush International, Houston Gulf, Houston-Southwest, May, Sugar Land Municipal/Hull Field, Weiser Air Park, West Houston, Westheimer Air Park, William P. Hobby, and the private sites at Channel Two Heliport, Flying Acres, Hickory Hollow Restaurant Heliport, Ponderosa Lakes Heliport, and Skyhaven).

Second place goes to Chicago, with 13. Fort Worth, Indianapolis, and New York City (mostly heliports) tie for third place, with 10 landing facilities each. Fourth place goes to San Antonio, with nine; Yakutat, Alaska, takes fifth place with eight, and Miami, Dallas, and Anchorage tie for sixth place with seven landing facilities each.

Source: Aircraft Owners and Pilots Association Airport Directory, 2001-2002 edition.

Mars or Bust, Take 3

Threading a spacecraft into orbit around another planet is always a delicate task, a finely balanced act of timing, positioning, and speed. But when a team of engineers and navigators shepherded NASA's Odyssey spacecraft into orbit around the Red Planet last October 23, the tension they felt was heightened: They were making their attempt on the heels of two widely publicized failures to get probes to Mars. "We've done everything humanly possible to get ready," said mission manager David Spencer of the Jet Propulsion Laboratory in Pasadena, California on the evening the maneuver was scheduled.

Extra testing and oversight added millions of dollars to the $297 million NASA budgeted to build, launch, and operate the Mars Odyssey orbiter. The probe, which was the first Mars-bound craft launched following the 1999 failures of the Mars Climate Orbiter and the Mars Polar Lander, lifted off from the Cape Canaveral Air Force Station on April 7 aboard a Delta rocket.

The team's extra efforts were rewarded when Odyssey fired up its engine and effortlessly swung into position to be snared by Mars' gravity. "How sweet it is," said retiring NASA administrator Dan Goldin.

Odyssey will spend until the middle of January gradually lowering and circularizing its orbit by dipping its solar panel wings into the thin Martian atmosphere to gently dissipate speed. The maneuver, called aerobraking, is similar to slowing a boat by lowering oars into the water. Once Odyssey has reached the altitude at which it will map Mars, it will take another two weeks to orient itself to begin its baseline, 2.6-year mission.

Odyssey's primary mission is to find subsurface water. "One of the key paths we're following with our Mars exploration initiative is trying to go down where the water went," said Spencer. Imagery collected by the probe is expected to reveal subsurface deposits of hydrogen, which scientists believe will most likely be bound up as water ice. The images also will be used to identify landing sites for a pair of probes that are expected to begin their journey to Mars in 2003.

The orbiter's tools of exploration are a thermal emission imaging system and a gamma ray spectrometer. A third instrument, the Mars Radiation Environment Experiment, is designed to measure the radiation around the planet, but the device is currently not working. Mission planners halted efforts to troubleshoot a problem with the instrument, which had been operating during the cruise to Mars, to concentrate on the critical engine burn the spacecraft needed to drop into orbit around Mars. Efforts to restore the radiation monitoring experiment are not expected to resume until after the aerobraking maneuvers are finished early next year, said Spencer.

—*Irene Brown*

UPDATE

China's New X-Plane

Cessna reports that it has sold a Citation X to the Air Traffic Management Bureau of the Civil Aviation Authority of China ("The People's Liberation Bizjet," Oct./Nov. 2001). The aircraft will be based in Beijing and will supplement the current CAAC fleet of two Citation Model 650s, which are used throughout China primarily to calibrate and monitor navigation aids. The Citation X will also be used for VIP travel.

ERIC LONG (2)

"Explore the Universe" displays instruments from the early 1900s, including this spectrograph, which was used by astronomers at Lick Observatory in California to record the spectra of stars.

Centuries of Upward Gazes

In a deliberately dark corner of the National Air and Space Museum's new exhibit, "Explore the Universe," a long black wooden tube is positioned at a 45-degree angle from the floor. A man standing on a ladder peers into one end of the tube, which is mounted on a scaffold-like framework. Behind it is a dim, life-size painting of an English country cottage. In one of the windows, a woman sits, writing by candlelight. Above the cottage, thousands of stars, illuminated from above by ceiling-mounted black lights, dot the sky.

This life-size diorama depicts a night in the life of William Herschel, a 17th century astronomer who discovered and catalogued thousands of nebulae and star clusters, leading him to propose the first theory that other galaxies exist beyond our Milky Way. It is just one of the scenes presented in this new permanent exhibit, which opened September 21, that portrays centuries of astronomical speculation, discovery, and advancement. Herschel's 20-foot, mahogany-tube reflector and its 100-pound, 18.5-inch-diameter speculum mirror are both on loan from Great Britain's National Maritime Museum. (The woman in the window? Herschel's sister, Caroline, who's helping him make notes on his observations.)

"Explore the Universe" walks visitors through 400 years of astronomy, illustrating how technology has gradually and continually expanded our knowledge of the universe. "As our tools for observing the universe changed, our universe changed," says exhibit curator David DeVorkin.

The journey begins with a tour of astronomical instruments used to develop initial understandings of the movement of celestial objects. Islamic astrolabes and a replica of the armillary sphere and portable mural quadrant—tools painstakingly developed to calculate star and planet positions based on the date and time of day—used by Danish astronomer Tycho Brahe are coupled with three-dimensional models that show early Earth-centric notions of the universe, with the sun floating in orbit somewhere amid Jupiter, Saturn, Mars, and Venus. The model created by 16th century astronomer Nicolaus Copernicus correctly placed the sun at the center of the solar system and Earth rotating on its axis. "It took years for this to take hold, of course, so we present artifacts that depict the transition from a tentative Copernican model to a solid Copernican model," says DeVorkin.

But even with that transition, the presence of thousands of stars that were dimmer than the planets and a variety of faint patches of light stumped astronomers. Herschel's work helped clarify the relationships—that the stars were outside of our solar system and the sun was one of many in a neighborhood later called a galaxy. "But he was never able to positively identify the fuzzy patches as galaxies beyond our own, or nebulas, the exploded remains of dead stars," says DeVorkin. "That would take better telescopes than Herschel's, and years' more study."

Around the corner from Herschel's majestic telescope is a scene representing the next leap in telescope

design, the 100-inch Mount Wilson observatory in California, shown in the exhibit with a simulated dome and the top portion of the famed telescope. Edwin Hubble sits at the eyepiece as he did in the 1920s and 1930s, when he postulated that galaxies exist and are moving away from one another. His research at Mount Wilson also suggested to him that the universe is composed of galaxies, not stars, and is expanding.

With the Mount Wilson telescope, DeVorkin and his colleagues at the Museum introduce photography as a critical development in astronomical study. A blink comparator, a device that enables astronomers to study stellar changes by comparing photographic images taken at various times, is a magnificent piece of technology that DeVorkin was thrilled to find. "I used one of these myself as a student," he says. "And being able to retrieve this brought back memories of an exciting time for me." Using M51, the Whirlpool galaxy, located near the Big Dipper, as a standard for comparison, the exhibit designers proceed to walk visitors through this century's numerous advances, including the spectroscopic study of stellar and galactic images, which help determine stars' compositions and galaxies' movements in relation to our own. Here, visitors are able to do their own comparisons of spectroscopic images.

In this final major component of the exhibit—which is introduced with an enormous three-dimensional piece of art that playfully integrates UFO mythology with a drive-in-theater theme—are displays showing the many ways information is gathered with computer technology. Sensors are placed deep in mines (to detect neutrinos, ghostly particles from the sun that pass straight through Earth), aboard balloon-borne instruments floated to the upper reaches of the atmosphere (see "Science Floats," p. 44), behind terrestrial telescopes, and, of course, in space. Such artifacts as the Hubble Space Telescope backup mirror—which, incidentally, did not have the same problems with resolution as the one actually launched—parts of the Chandra X-ray Astronomy Observatory, the Johns Hopkins Ultraviolet Telescope, the Smithsonian Astrophysical Observatory's Z-Machine, and the twin Keck Observatory interferometer are all on display to demonstrate how scientists in the last few decades have begun to divine the large-scale structure of the universe and its evolution.

And as our observational capabilities expand, DeVorkin says, so does our ability to predict what types of instruments we'll need in the future. "The majority of the universe that we're in is something we can't see yet," he says. "The dark universe—the matter that is not visible but which might be critical to the mechanics of the universe—is our next great unknown, and that's one of the places our next generation of instruments will be going." Thus, the final component of the exhibit is a section devoted to up-to-the-minute discoveries, as posted on a variety of continually updated bulletin boards. "I really think this is going to be a fun exhibit to maintain over the years," DeVorkin says.

—Eric Adams

The new gallery also features a backup mirror for the Hubble Space Telescope (left), a one-fifth-scale model of the Hubble telescope (center), and a model of the dome at California's Mount Wilson Observatory (right).

MUSEUM CALENDAR

January 3 "Our View of Mars." Center for Earth and Planetary Studies geologist Jim Zimbelman discusses the human view of Mars, as influenced by the findings of the Mars Global Surveyor. Einstein Planetarium, 12:20 p.m.

January 26 Monthly Star Lecture. Public telescopic observing will follow the lecture, weather and time of sunset permitting. Einstein Planetarium, 6 p.m.

Curator's Choice
Once a week a Museum curator will give a 15-minute talk about an artifact or subject of interest. Meet at the Museum Seal near the Information Desk at noon. Dec. 5, "General Hap Arnold"; Dec. 12, "The Digital Universe"; Dec. 19, "The Bell X-1 Rocket Engine."

Garber Preservation, Restoration and Storage Facility
Visit the Suitland, Maryland workshop where air- and spacecraft are restored. Free tours last about three hours; make reservations at least two weeks in advance. For more information, call (202) 357-1400.

Samuel P. Langley Theater
Experience the thrill of films produced in IMAX and projected onto a screen seven stories wide and five stories high. The theater box office is on the Museum's first floor.

Mutual Concerns of Air and Space Museums
Don't miss the 2002 Mutual Concerns of Air and Space Museums seminar, sponsored by the National Air and Space Museum and the American Association of Museums. The seminar will address some of the most challenging issues museums face today, such as fundraising, safeguarding visitors and collections, and conservation. March 16–19, Hilton Hotel, Crystal City at Washington Reagan National Airport. More information: (202) 289-9114.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu *or call the Smithsonian Information line at (202) 357-2700; TTY (202) 357-1729.*

Pushback: Newark Airport, 8:45 a.m.

The chirping of the alarm clock woke me from a deep sleep. I cursed when I saw "5:30 a.m." and hit the snooze button for five more minutes.

"Who could possibly need to leave New Jersey this early in the morning?" I thought as I made my way to the shower. The flight's departure time was a sensible 8:45 a.m., but I had to wake up far earlier so I could shower, pack, and drive the hour and a half to Newark Airport.

The drive across the Hudson River took longer than usual. Seething, I crossed the George Washington Bridge at 10 mph. But no matter how bad the traffic, the view of the Manhattan skyline was always majestic.

The drive, especially for New York- and Newark-based pilots, was usually the most stressful part of the day. I was looking forward to getting to the airplane for my three-day trip. For me, flying has always been therapeutic, whether it's a multi-million-dollar airliner or a $50-an-hour rented Cessna.

I met the rest of my crew at Operations.

"Ever laid over there before?"

"Yeah, there's an excellent Mexican restaurant near the hotel."

"Perfect. Just what the doctor ordered."

"See you up at the airplane."

Climbing into the cockpit, I felt like my day was about to get better. There's something relaxing about making a nest for yourself in a cockpit seat, accomplishing all your preflight checks, and being able to stand at the door and greet passengers.

When we finished our cockpit checks, the main entry door slammed and locked behind us. The head flight attendant poked her head in the cockpit and announced, "Cabin's ready."

Pushing back, the tug driver had us facing east. We waited for him to disconnect and give us the all-clear signal. After starting our engines, I reached down to pull my sunglasses out of my flight bag and caught what seemed like a flash of lightning out of the corner of my eye.

"Did you just see that?" the captain asked.

I looked up and saw thick black smoke beginning to drift across lower Manhattan.

"What happened?" I replied. "Is that smoke coming from the World Trade Center?"

"It looked like an explosion," the captain said.

"Was that smoke there when we pushed?" I asked.

"I don't think so."

We spent the next few minutes wondering if we had seen secondary explosions due to an out-of-control fire. Whatever the case, the sight was horrifying.

"I hope they have a way to get those people out of there," I said.

Since our tug driver had already disconnected from his intercom and pulled the tug away from the airplane, I got on the radio and called Operations. Knowing they usually had a TV on somewhere in Ops, I thought they might clue us in to what we were seeing. But they seemed surprised by what we were describing. This was the first they had heard of it.

As we switched over to Newark ground control to start our taxi, it was obvious that everyone on the frequency had witnessed the same thing. In between taxi instructions, a crew member on one of the other aircraft on the frequency asked, "Any idea what's going on across the river?"

"Stand by, we're checking" was the terse reply.

As we taxied south toward runway 4L, we watched the horror unfolding only miles away. In the few minutes we had been taxiing, the smoke

ETIENNE DE MALGLAIVE

had definitely become more intense.

The intercom chimed in the cockpit. One of the passengers had noticed the smoke and asked a flight attendant what was going on. We told her we weren't sure. We were still thinking it was simply a terrible fire in one of the Trade Center towers, and we hoped it would be under control soon.

As we waited in the long line of airplanes ready for departure, another crew member asked ground control if they had any updates. This time, the ground controller hesitated, then replied, "We think we know what it is, but we don't want to say it over the radio."

One of the navigational aids that we use in the airplane is an Automatic Direction Finder, which is essentially an AM radio receiver. During playoff seasons, we occasionally tune into radio stations to get sports scores for our passengers. Today, we frantically tuned to a New York City news station.

The radio was reporting that it appeared an airplane had hit one of the World Trade Center towers. The initial reports said it was a small twin-engine airplane.

> I reached down to pull my sunglasses out of my flight bag and caught what seemed like a flash of lightning out of the corner of my eye.

We wondered if it was a LaGuardia-bound commuter airplane that had had engine trouble and had been unable to hold altitude. Maybe it was a sightseeing flight, common along the Hudson River, that had strayed off course?

As we looked across the river at the billowing smoke, I picked up another airplane flying low across the horizon from south to north. This was a common arrival pattern for LaGuardia airport, but the aircraft seemed much too low and much too fast. I followed it along, pointing it out to the captain. Both of us watched in stunned horror as it hit the other tower.

Damn, somebody got mesmerized looking at the fire and wasn't paying attention to where he was flying, I thought. But then—no. No one could be that distracted.

The captain and I looked at each other, but neither of us could find words. Suddenly, the silence was broken by the ground controller. "All right. Everybody shut them down. I just saw a 737 or an MD-80 hit the second tower. The World Trade Center is under attack."

Attack? I briefly thought about the scene in *Diehard 2* in which the terrorists reprogrammed navigation aids, causing airplanes to crash. No, couldn't happen. Too far-fetched.

I began to think about the safety of our passengers. I looked over at the captain. "Do we really want to be sitting here with our engines shut down if New York is under attack?" I asked.

"Hell no!" he said.

I looked at where we were in the lineup and saw an intersecting taxiway that would give us access to the runway. I immediately began pulling up data from the computer to see if we could take off with the amount of runway remaining. It was going to be close. We decided to switch to the tower frequency; if everyone in front of us was indeed shutting down, we wanted to see if we could back-taxi down the runway for takeoff.

The tower frequency was controlled chaos. Three aircraft on an approach were being sent around and handed back to approach control. We heard another captain, who had the same idea as us, ask if he could back-taxi for takeoff. The controller replied that Newark airport was now closed and all aircraft should return to the gate.

"Does the captain's emergency authority override that?" I asked.

"I don't know," the captain replied. We tried to decide just how badly we wanted to get airborne right then. Listening to the radio reports in the background, I had repeatedly heard the word "hijack." We decided that we really couldn't be sure of the security of our own aircraft.

We switched back to ground control and told them we would be pulling out of line and returning to the gate. It was a long, slow taxi back. Ground control frequency was strangely quiet. As we pulled into the gate and shut down the engines, the captain looked over at me and said, "I think we just witnessed history."

A few nights later, I reached over to set my alarm again for the first time since September 11...and started crying. I thought about how different things were when my alarm clock went off that morning, and I wished I could snap my fingers and go back to the days when the most significant problem of the day was the morning traffic.

—*Anonymous*

When Pigs Fly

KEVIN BUTLER/SKYPIG PRODUCTIONS

Bill Rousseau lives in Grain Valley, Missouri, about 25 miles east of Kansas City— in his words, "the center of the universe for barbecue. It's a religion around here." Along with his skydiving partner, Marty Edwards, Rousseau for years has barbecued in the back yard and the driveway and watched barbecue contests on TV. (Bill specializes in pork ribs; Marty's more a beef brisket man.)

One fall night in 1990, Rousseau and three members of the Missouri River Valley Skydivers parachuted into the first high school football game of the season, carrying the game ball. "There was a barbecue contest going on across the street," Rousseau says, "so we went over with our ground crew and wandered around. I'd never really been to one before, and you know, those people were having too much fun. So we said, 'We can do this.' "

One interesting thing, Rousseau discovered, was the "many different kinds of barbecue grills. There's thousands of different cooker designs. People have built them to look like steam engines, like armadillos, like pigs. I've seen them built into the trunks of cars. There's one guy down in Texas who built one to look like a large revolver."

A gun?

"Yeah, the smoke comes out of the barrel. So I saw you could do pretty creative things with barbecue grills." A few weeks later, Bill discovered a wrecked Cessna 185.

"We were out at the airport in Lexington, Missouri," Rousseau explains. "I'd made a couple skydives that morning, and then it got cloudy and windy so I was just wandering around. I saw this fuselage and thought, *Hmm, that would make an interesting grill.*"

The 43-year-old airplane had been damaged in a thunderstorm. "One of the tie-downs broke under the wing, and the storm flipped it over on the tail. The insurance company totaled it, so it ended up in a scrap yard.

"We jump out of Cessnas, and because this one had been flipped over, the landing gear was still in good shape. They could take those parts off and use them on our jump planes. I asked them, 'What are you going to do with the rest of this?' "

"We drug the fuselage home on a trailer and stuck it in my garage," recounts Bill Rousseau. "Then the next time Marty came over, I told him, 'We're going to build a barbecue grill out of this.' He told me I was crazy, and I said, 'That's beside the point, we're gonna build a grill out of this.' "

The answer, after all the useful parts had been stripped off, was "Not much." Rousseau was welcome to the rest of the airplane.

"We drug the fuselage home on a trailer and stuck it in my garage. Then the next time Marty came over, I told him, 'We're going to build a barbecue grill out of this.' He told me I was crazy, and I said, 'That's beside the point, we're gonna build a grill out of this.'

"We sat there for like two days in lawn chairs, drinking beer, trying to figure out how we were going to do this," Rosseau says. "Finally we just ordered some steel, fired up the cutting torch, and went after it.

"To make it into a smoker, basically, function had to follow form. We built a heavy steel fire box, lined it with fire brick, then hooked it, using large steel pipes, to the cook box, all inside the cockpit of the airplane. If you're familiar with Cessnas, you open the luggage door to access the fire box, where we put the charcoal and the wood.

"The pilot's door is not on it. The passenger door is, though; that's on the show side of the plane. It's painted dark blue and silver, and we've got nose art too.

"Then we hit on the idea of putting a rotisserie inside the cockpit, so Marty salvaged an elevator door mechanism from work and we mounted it inside the nose of the airplane. Basically it looks almost like a Ferris wheel inside there, four long thin racks going around in a circle."

The barbecuing team, originally just Bill and Marty, became known as the Swine Flew. Their motto: "There is no cure."

"Our only rule," Rousseau explains, "is if anybody gets caught taking it serious, they can't play anymore." Depending on personal schedules, as many as five or six other skydivers, private pilots, and friends join the two at cooking contests, where Swine Flew has won over 75 ribbons and trophies. Certainly their Cessna cooker attracts at least as much attention as the food produced in it.

"The largest single animal we've had in there was a 265-pound-dressed-weight whole hog," Rosseau says. "That thing was *huge.* One time I put 24 or 25 full-size turkeys in there and smoked those."

It's interesting, I say, that turkeys don't really fly, yet they all got in the airplane.

"Well, they went willingly, and they were delicious."

—*Richard Sassaman*

YOUNG TURKS

BY ROGER A. MOLA ★ THE UNITED STATES HAS ITS THUNDERBIRDS. TURKEY HAS ITS STARS.

PHOTOGRAPHS BY LUIGINO CALIARO

The hangar at Naval Station Norfolk in Virginia was packed with mom-and-pop vendors. I rounded a corner and there, by the aluminum siding display, sat *Turk Yildizlari*—the Turkish Stars—elbows on knees, slumped on wire chairs. Norfolk's invitation to the annual airshow had been accepted with pleasure, but the Turkish air force demonstration team did not have the money to send both pilots and airplanes. So they sat, desperately bored, spring-loaded for visitors.

I introduced myself as an aviation journalist and a representative of the International Council of Air Shows. "I'm planning a visit to Turkey at the end of this year," I began. "Maybe I could see your base in Konya?" My plan was to deliver ICAS training materials to help the air force prepare for its upcoming 90th anniversary airshow.

"What have you seen of Turkey?" asked Taskin Buyukyurtsever. Each pilot brightened in turn as I mentioned his hometown. As we talked shop, the crowd in the hangar made a hasty retreat, suggesting that something good was flying. The team members' eyes followed the crowd's heels and I watched the pilots slump anew. I promised to write them when my plans firmed, and in October 2000, after a stopover in Ankara to consult with Turkish air force headquarters, I arrived at Jet Base Konya and was met by public affairs crewman Buyukyurtsever and team boss and squadron leader Ahmet Civelek.

I accepted a cup of piping hot sweet tea (*cay*) served in the standard squat, clear glass with metal rim, so hot I had learned to hold it with a

Enter, stage right: Turkey's air demonstration team, the Turkish Stars, hopes to turn the airshow world upside down.

makeshift oven mitt. (In Turkey, refusing *cay* is akin to shrinking from an extended hand.)

For our briefing, we were crammed between Civelek's desk and a conference table covered in sheepskin. On a bookshelf was a sphere of blue glass embedded with a mock eyeball, a talisman that, according to folkloric tradition from Turkey's ancient past, deflects bad luck wafting from the stares of strangers. In Turkey, the symbol, *nazar boncuglu*, appears on pendants, pins, T-shirts, and rings. Cars are bumper-stickered, painted, or placarded with a blue bead coming, going, or both.

Civelek had made the *nazar boncuglu* for his team. He had built a tiny F-5 that rested on a field of wool, capped by a tumbler representing the Anatolian sky and by a cardboard *nazar*. Outside, Jet Base Konya is guarded by an eight-inch-diameter ceramic eyeball at its front door.

The Turkish air force—Tuaf—is one of the world's oldest, founded in 1911 under the Turkish Aviation Commission. That July, Cavalry Captain Fesa Evensrel and Engineer Lieutenant Yusuf Kenan were dispatched to the Blériot School in France. By February 1912 they were aviators, and by year's end, Turkey had opened its own air school and boasted 17 aircraft, including three Deperdussins, four Bristols, and a Blériot.

Last spring, Turkish Aerospace Industries completed a replica of that Blériot to tour the Turkish countryside. At the Turkish International Air Display on June 1, which celebrated the Tuaf's 90th anniversary, it overflew Izmir Bay before baking on the apron at Cigli Airfield, Izmir, along with the Turkish Stars' C-130 as well as dozens of static-display aircraft, including Turkey's frontline fighter, the F-16, and military demonstration teams visiting from 16 countries. But that was months ahead. First, *cay* at Stars' headquarters, Jet Base Konya.

All under the gaze of Mustafa Kemal. A portrait of Kemal, who in 1923 founded the Turkish Republic (and who was later called Ataturk, Father of the Turks), graces every square, office, gas station, restaurant, and most homes in Turkey. In 1925, Kemal launched the Turkish Air Association in order to get young people interested in flight, and to create a tangible symbol for his plan to modernize the Turkish Republic. Ataturk called for public donations. Hundreds of thousands of peasants dipped into wedding dowries and sold handmade goods for the cause. By 1932, grassroots campaigns produced enough money for the purchase of 350 aircraft, each bearing the name of a community. On statuary and banners the Tuaf honors Ataturk's words, "Istikbal Goklerdedir"—roughly, "The future is in the skies."

The Turkish Stars is not Turkey's first demonstration

Left to right: Turkish Star Taskin Buyukyurtsever brings the audience to its feet at the Turkish International Air Display. The show opened with a parachute drop of a portrait of Mustafa Kemal, whose words "The future is in the skies" inspire the air force. The tip tanks on the Stars' NF-5s now carry airshow smoke fluid instead of fuel.

LEFT AND BELOW: ROGER MOLA

team, simply the first with a flight of seven and the first to routinely fly for the public. The progression of airplanes and pilots is glorified in posterboard and plastic models in the lobby of the squadron command.

Early demonstration pilots were more accurately test pilots. In 1964, four combat instructors who had mastered the F-86E presented exhibitions, mainly to the Tuaf command. The McDonnell F-4 and Northrop F-5A soon followed, then, in trickles from the Netherlands, the NF-5A/B. In Dutch service, NF-5s evolved into trainers; as the Netherlands modernized, the Tuaf bought them piecemeal. One of the first refinements was the installation of a *nazar boncuglu* in every cockpit.

By 1992, the Tuaf launched a four-ship team, established as a subdivision of the elite fighter weapons school, which was attended by the top guns of Turkey. The name "Turk Yildizlari" was approved in 1993, and the livery was reworked from brown-tone camouflage to carnival-red and white. The show could go on, partly because mainline fighters could take the NF-5's place. Following the 1991 Gulf War, the Tuaf

Most airshow sites are chosen by the team itself. "We often pick our hometowns to fly so we can at least say we got a thousand people to come," said formation leader Tamer Sireli. "They are often the pilot's family and the rest of the village."

As the smoke settles, the Stars crank New Age music from a ground-based speaker system. In a full air demonstration length of 20 maneuvers in 25 minutes, the accompaniment is a heraldic chorus with a techno beat, melding percussion with refrains of computer-generated jet noise, staccato brass, and a haunting, nautical undercurrent.

ROGER MOLA

Inset opposite, top to bottom: Pilot Ercan Bicakci's jet awaits a Star. An Army helicopter displays Turkish flags and base and unit banners, and dangles a pair of paratroopers. The NF-5s' paint scheme is subject to the baking sun on the ramp at Jet Base Konya; the elaborate bird on the aircraft's undersides fares better (opposite).

became oe of the largest recipients of U.S. surplus weaponry.

In 1994, the Turkish Stars launched their first official display in Diyarbakir, a southeastern city that rose from the trading posts and inns of the ancient Silk Road. As of 1996, the team had 10 NF-5As and two NF-5Bs, a tidy squadron building, plus a commentator, a weather services officer, six non-commissioned officers handling public relations, and 13 officer pilots.

Inside the Stars' headquarters, Buyukyurtsever delivered his impromptu read of a computerized script. "We represent the concrete discipline of Turkish Armed Forces and display the high performing effectiveness of modern Turkish Air Force to the entire world. Our motto that we always follow is 'Peace at Home, Peace Abroad.' " Buyukyurtsever alternated between tea, cookies, and keyboard.

Buyukyurtsever clicked "Next Page" with his mouse. "Every maneuver in the display confirms the high confidence of the Turkish people and our allied nations on Turkish armed forces," he recited from the screen. "We create enthusiasm to aviation among young people." Buyukyurtsever refilled his *cay*. "We are full of amazing emotion of being honored," he read.

Our group moved to the briefing room, appointed in Cineplex comfort with a video projection system, 12-speaker sound system, and 75 electric blue La-Z-Boy-style stadium seats. I remarked on the room's plushness. "I don't know why the U.S. briefing rooms are so uncomfortable," said Nihat Yalcindag, Left Wing. "I see they often use airplane seats. We sit in those enough.... Why not be comfortable?"

The Stars gathered around a television to review their most recent show video. Yalcindag collected a stack of sugar cubes, which, given the flow of *cay*, were in ready supply.

"These seven are jets parked near the taxiway," Yalcindag began, arranging the cubes. "We walk between the audience and the NF-5s this way, in a line." He inched a toothpick between the cubes (the aircraft) and some biscuits (the audience). "We then break from the line one by one, turn and salute the highest ranking member of the audience, shake hands, and walk to the jet."

Unlike the U.S. Blue Angels and Thunderbirds, the Stars are not a flying recruitment poster. As former narrator Orhan Tamer summarized, "Recruiting is not an issue in Turkey. Our children are recruited congenitally." With few exceptions, service is compulsory; one must enter before turning 35 and serve for eight to 18 months, depending on the assignment's level of hardship. Military rotations may include coast guard, navy, air force, army, the *gendarmerie*, a kind of community police, or border patrol, in which the chief pastimes are swapping stories of hometowns and sipping tea.

The message that the Turkish Stars convey to their Turkish audiences is twofold. They try to instill pride but also to soften the face of army and air force assets, which for 15 years of civil strife were Bell Textron, Agusta-Bell, and Eurocopter helicopters. Turkish forces put down clashes with ethnic groups, chiefly Kurds, fighting for autonomy in the rugged hill towns of the southeast part of the country.

Outside the Turkish Stars' offices, their jets sat on the ramp. Their vivid red and white was more stunning in contrast with the squadrons of NF-5s and a larger assortment of aircraft in desert camouflage. Seeing the daunting collection of old iron, it was easy to forget that the Tuaf flies 240 F-16s, mainly model Cs.

At the time of my visit, the Tuaf also had about a hundred F-4s, with nearly half to be replaced this year with Phantom 2000s, which are F-4s upgraded by Israel Aircraft Industries. Cadets begin training in the Cessna T-37, graduate to the Northrop T-38, then learn fighter tactics at Konya, which has 30 F-5s in two squadrons. One squadron instills advanced combat technique. The other serves the Turkish Stars, which flies 10 jets to every show. Seven perform while three remain at the nearest base as spares.

Wingtip tanks that once held fuel now hold airshow smoke fluid. Installation of the smoke system entailed permanently disabling the NF-5's air-to-air refueling capability. With only centerline tanks, the Stars have still wandered as far as England and Denmark, in multiple hops of the maximum 630 miles. (A transatlantic trip would require shipping the jets.) But currently, Turkish air command has decided to limit operational range to one refueling.

Within that zone, Turk Yildizlari paints the town red. Literally. "I guess this type of paint might be used to paint a car or a house," figured Civelek, "but it is mixed a little different to evaporate." The Stars first experimented with tinted jet fuel as airshow smoke to match the Turkish flag. Several more blends were too volatile or not volatile enough. The team finally mixed a form of house paint with standard gasoline. In the right conditions, most of the paint evaporates before it mists the audience. Not so over the concrete apron at Konya, which is flecked with red and white.

As the smoke settles, the Stars crank New Age music from a ground-based speaker system. For a full air demonstration of 20 maneuvers in 25 minutes, the accompaniment is a heraldic chorus with a techno beat, melding percussion with refrains of computer-generated jet noise, staccato brass, and a haunting, nautical undercurrent.

The Stars appear at up to 20 cities yearly, including two abroad (appearances last year included Austria and Romania). Most domestic sites are chosen by the team itself. "We often pick our hometowns to fly, so we can at least say we got a thousand people to come," said formation leader Tamer Sireli. "They are often the pilot's family and the rest of the village."

Including pilots, the team arrives in a complement of 45—60 if they go abroad. "Normally an organization in another country pays for all fuel and expense if they invite us," said Sireli. "With big nations that's not difficult,

CENTER: ROGER MOLA

Left to right: A final boarding call puts a Stars pilot in the cockpit for a performance. The Air Display was awash in VIPs, including Turkey's president, Ahmet Necdet Sezer (in gray suit). The team's traveling merchandise mart offers Turkish Stars souvenirs, including an NF-5 air freshener. "Maybe in five years we will have fan clubs?" wondered Orhan Tamer.

but Slovakia, Armenia—certain facilities are not there. They don't even clean their runways, and it is unsafe for us to land."

The Stars run an impressive merchandise market, from an NF-5 air freshener to flightsuit patches, window stickers, and lapel pins. "We do not make a profit from these things," said Buyukyurtsever. "We use the money to make more merchandise and it just makes us better known." Orhan Tamer started with a semi-trailer and designed a custom rig complete with folding staircase, souvenir racks, vast bins for caps and posters, and a credit card processor.

Domestically, all the team's costs are borne by the state; in contrast, the U.S. Blue Angels and Thunderbirds require fuel, lodging, and a fleet of cars and amenities. "No sponsor is asked for money," says Buyukyurtsever. "We don't need money, we need people to watch our flight," Tamer said. "Maybe in five years we will have fan clubs? The typical Turkish entertainment is a barbecue by the roadside, or a walk in the forest. Our people do not know what this is: 'Airshow? What is that?' "

"At a first-time show we might get a few hundred," said Buyukyurtsever. "Next time maybe 4,000, and if we go back the third year it will be up to 20,000."

The Stars prepare from September to March, then fly up to 35 shows in a season. During show season, the F-5 Konya squadron lends combat training support. From May 20 through June 10, 2000, the Tuaf participated in NATO's Dynamic Mix 2000, an unprecedented show of cooperation with its neighbor and centuries-old rival, Greece. Relations had been especially chilly since the 1974 Cyprus crisis, with that island nation still divided north and south, loyal to either Turkey or Greece. "I just heard that our neighbor—lovely Greece—will establish an acro team with their F-16s," said Tamer. "They have had nothing before in their air force history and they do this because Turkey does this."

Before departing for an airshow site, the U.S. Blue Angels know the parking spot of each jet, down to the GPS latitude and longitude's nearest second. And to perform a demonstration over featureless terrain, U.S. teams often require visual aids. The Blue Angels Support Manual calls for an artificial showline that is visible to pilots from three nautical miles away and recommends a 5,000- by 40-foot strip of white plastic with a centerpoint marker opposite the center of the crowd.

Remote sites for most Turkish shows are bordered by nondescript farms: brown farms, green farms, greenish-brown farms, brownish-green farms. "Do you set an artificial flightline?" I asked. "How do you mark the aerobatic box?"

Commander Civelek leaned forward. "Let me see this manual." Three pilots crowded in to see. Buyukyurtsever translated the captions, and Civelek turned the Support Manual diagram sideways, then upside down. He shook his head and grinned. "Our lead picks a checkpoint," he said. "The checkpoint that is there, that is in the world. We just look at the Earth with our eyes."

Civelek burst into rapid-fire Turkish, pointed to the manual, and he and his pilots erupted in laughter. "We use eyes!" he said.

In an airshow display, Turkey performs for a domestic crowd but is also hoping to show its Western neighbors it would be a valuable addition to the European Union. Its military strength, as a NATO member since 1952, is its strategic position between Europe and the Middle East, where it can easily help reinforce the no-fly zone over Iraq, to its southeast. For the 90th anniversary, the Tuaf staff emphasized one of the show's intentions in its letters of

"Our lead picks a checkpoint, the checkpoint that is there, that is in the world. We just look at the Earth with our eyes." Civelek burst into rapid-fire Turkish, pointed to the manual, and he and his pilots erupted in laughter. "We use eyes!" he said.

invitation to every armed force of the European Union. "We believe that your participation will help a lot to foster the relations between our air forces," the staff wrote in English.

But Turkey falls short of European Union economic standards, and the 90th anniversary show came at a critical point in accession talks. Turkey has suffered triple-digit-a-year inflation as recently as 1999, and in 2001 national government expenditures bloated to a boggling 48.4 quadrillion Turkish lire (TL), more than $40 billion. Since the autumn of 2000, the International Monetary Fund has pumped emergency loans into Turkey's central banks three times. The most recent: $10 billion, three weeks before the airshow. Bucking EU mandates, the TL was floated last February; by showtime, its value had diminished to 1.2 million TL to the dollar; now it is past 1.6 million. "We had difficulty with delivering this show because of the currency crisis," said Colonel Ismail Tas, incoming Tuaf secretary general.

Yet deliver it they did, using it to improve the country's standing among EU members. The Turkish Stars took diplomatic flights with visiting teams and dispensed charm, hospitality, and sweet tea to 16 foreign air forces, some belonging to EU countries, others that were fellow EU hopefuls. Afterward, the teams enjoyed a rollicking, aromatic, tiki-lit bash at Cigli airfield, with an open bar and barbecue.

A secure Turkish air base like Cigli had never before been opened to the public, but senior command hopes that this first experience will mark a new era of outreach within and beyond Turkey's borders. At Cigli, as elsewhere in military ceremonies, June's anniversary show opened with a parachute drop of a 40-foot banner bearing a portrait of Ataturk. In a canvas on Cigli's main hangar, Ataturk looked to the skies: Istikbal Goklerdedir. Turk Yildizlari hopes to bring that vision to the United States—next time, along with their jets.

Special Report

Aftermath

by Lester A. Reingold

What's remarkable about this country's approach to aviation security, following September 11, is how broadly and rapidly it is being overhauled. Though the overhaul was triggered by the four coordinated airliner hijackings, it is extending well beyond the specifics of those crimes.

Cockpit doors are being reinforced, even though there's no evidence so far that the September hijackers forced open any doors. The airport screener workforce has been targeted for reform, even though the weapons the hijackers used would not have caused screeners, under regulations then in place, to halt them at the checkpoints. Washington Reagan National Airport remained closed long after other U.S. airports and finally opened only with special restrictions, even though it was Washington Dulles International, not Reagan National, where one of the hijacked flights originated.

Though these changes do not address the security breaches of September 11, they are not unwarranted. One post-disaster report concluded: "The U.S. civil aviation security system is seriously flawed and has failed to provide the proper level of protection for the traveling public. This system needs major reform. Rhetoric is no substitute for strong, effective action." The report was prompted, though, not by the recent hijacking assault, but by the 1988 bombing of Pan Am 103 over Lockerbie, Scotland. A presidential commission on aviation security and terrorism issued it in 1990.

Testifying before the U.S. Senate on September 20, 2001, Captain Duane Woerth, president of the Air Line Pilots Association, stated: "I suspect that many of us believed that, although flawed, our security system was generally doing the job that it was intended to do. Unfortunately, that mindset may well have been at the root of what enabled the 19 terrorists to perform their acts of unspeakable devastation."

Perhaps the most far-reaching change of all is in that mindset. While in the past, vigilance would increase following a terrorist incident but relax as memory of the incident dimmed, the September 11 attacks were so ghastly that top-down changes, once deemed improbable, now seem inevitable. These include new airline and airport procedures, new regulations, and a lot more government investment in the development of new technologies.

Among the first things discarded was what's known as the "common strategy" for handling hijacking. ALPA spokesman John Mazor points out that the motto used to be "Accommodate, negotiate, and do not escalate." That philosophy was based on the assumption that the hijacker was as interested as everyone else in getting the airplane safely on the ground. But a terrorist bent on suicide has more options and a lot fewer constraints.

Well before September 11, there were several incidents that foretold the advent of airborne suicide terrorism, and perhaps the biggest failure by those responsible for the security of air travel was the failure to recognize the likelihood that airplanes themselves would

SUE OGROCKI/REUTERS NEWMEDIA INC./CORBIS

A major security challenge is the screening of passengers. The Computer-Assisted Passenger Pre-Screening System profiles travelers based on information in an airline's reservation system.

be used as weapons. In 1994 a FedEx employee used hammers and a speargun to attack the three pilots of a FedEx DC-10, hoping to crash the wide-body into the company's Memphis hub. Two of the pilots managed to wrestle the hijacker into submission before the airplane made an emergency landing at Memphis. That same year, terrorists from the Armed Islamic Group plotted to fly an Air France A300 into the Eiffel Tower to punish France for supporting the government of Algeria against a takeover by Islamic extremists. They hijacked the aircraft and killed three passengers, but they were in turn killed by French commandos after the flight landed in Marseilles to refuel. In 1987, a recently fired airline employee smuggled a pistol onto a Pacific Southwest Airlines flight. He shot both pilots and the British Aerospace 146 then crashed, killing all 43 on board. And in 1974, a man named Samuel Byck planned to assassinate President Richard Nixon by hijacking a Delta Airlines DC-9, shooting the pilots in flight, and then aiming the aircraft at the White House (Byck had sent a tape outlining his plan to a newspaper columnist before the flight). The DC-9 never left the gate at Baltimore-Washington International Airport, and Byck was killed in a gun battle.

The new common strategy against hijacking is "Defend the cockpit at all costs." Many U.S. airlines began adding deadbolts and reinforcement bars soon after the September hijackings. They also changed inflight procedures, calling on pilots and flight attendants to keep the door closed during flight and communicate primarily by interphone. Under new Federal Aviation Administration regulations, flight attendants no longer carry cockpit keys.

The first four of 17 recommendations to Department of Transportation Secretary Norman Mineta, made three weeks after the attacks by a "rapid response team" on aircraft security, also focused on the cockpit door. The team, whose members were drawn from airline management, aviation unions, and the aerospace industry, called for a new cockpit door design within six months and retrofit of the entire U.S. fleet a year after that.

If the cockpit is being turned into a fortress, should there be guns inside to defend it? A weapon in the cockpit is illegal under current FAA regulations, but ALPA recommends a voluntary program. Under the ALPA plan, a pilot who signs up would go through extensive background checks, psychological evaluation, and firearms training. Then he or she would be deputized as a federal law enforcement officer and carry a federally authorized weapon. The ammunition would be frangible, which means the bullet disintegrates on impact with a hard surface, so it would be unlikely to ricochet or seriously damage the aircraft. Such armed pilots would not take the place of federal air marshals; in fact, the FAA has begun a drive to hire and train thousands of armed marshals to fly aboard both domestic and international routes.

Firearms aren't the only means to foil a hijacking. A variety of non-lethal devices are being hurriedly reviewed. One that is making its way before the FAA, congressional committees, airlines, and unions is the Laser Dazzler, manufactured by LE Systems. It looks like a large flashlight and emits an intense beam of green, pulsating light. The laser is harmless even at close range, but the bursts of light leave those who see them disoriented. The device

could also be mounted on an aircraft bulkhead and, should there be a threat in the cabin, activated by a remote switch.

Another defensive weapon can be the aircraft itself. In a normal flight, says Captain John Cox, ALPA executive air safety chairman, "the idea is don't spill the coffee. But with a hijacker on board, a 2-G maneuver would double his weight, and that could help disable him." There are risks, though, in attempting aerobatics with an airliner. Cox issued a bulletin to ALPA members warning, for example, that loose objects can be turned into projectiles and that "aggressive, sustained control inputs, especially at high altitudes, may cause an aircraft upset that could lead to loss of control." The DOT's rapid response team recommended that such maneuvers, including dives and intentional depressurization, be used only as a last resort.

The September 11 hijackers succeeded not only in diverting four aircraft but also in keeping ground authorities largely in the dark while they did so. Many technological fixes are being proposed to prevent that from happening again. These include a transponder that continues to transmit aircraft identification, altitude, and hijack signal, even if switched off from the flight deck. Honeywell is considering some form of "panic button" that would immediately downlink the data that is routinely stored in the cockpit voice recorder and digital flight data recorder.

Remember HAL, the computer with a mind of its own in the movie *2001: A Space Odyssey*? Picture hijackers aiming 767s at the World Trade Center and the aircraft, like HAL, refusing to do as commanded. Such a safeguard appears feasible. Even before September 11, NASA was exploring a number of "refuse to crash" technologies that would keep pilot mistakes from leading to accidents. Enhanced ground proximity warning systems (EGPWS) are already in use. Coupled to the radar altimeter, plain-vanilla EGPWS warns the pilot when the airplane is too close to the ground. The enhanced version consults a terrain database to warn that there's a likely collision ahead. To turn this system into a hijacking countermeasure, those advisories would have to be converted into orders.

The next step could be to wrest control from the pilot altogether. Once a hijack attempt becomes evident, someone on the ground takes over and flies the airplane. James Coyne, president of the National Air Transportation Association (NATA), says that most of the ingredients for this scenario are already in use, such as flight management systems, fly-by-wire control, and auto-land capability. What's still missing, he says, is a long-awaited broadband data link, which would replace much of the routine voice communication between air and ground. ALPA representatives, among others, are more skeptical. They point to the risk of accidental or even intentional misdirection from remote aircraft operators, and FAA spokesman Les Dorr classifies such technologies as long-term, since even the military has perfected remote control only with relatively simple, single-engine aircraft.

Of course it's a lot safer to prevent a hijacking than to foil one in progress. That entails keeping terrorists, weapons, and bombs off aircraft in the first place. ALPA's testimony to the U.S. Senate recommended 30 near- and long-term actions to improve airline safety. For example, the union suggested that the Immigration and Naturalization Service not be allowed to use scheduled airline flights to deport illegal aliens without the escort of armed INS agents. Currently, the INS allows up to 10 deportees to travel unescorted on a flight with paying passengers.

In the aftermath of September 11, private security companies and the airlines that hire them have come under fire. Poorly trained, underpaid screeners often miss the test weapons used to gauge their performance. Suddenly

In 1994 terrorists from the Armed Islamic Group plotted to fly an Air France A300 into the Eiffel Tower. They hijacked the aircraft and killed three passengers, but they were in turn killed by French commandos after the flight landed to refuel.

there has been agreement on the need to federalize or otherwise upgrade the screener workforce. (As this issue went to press, the U.S. Congress had not reached agreement on an aviation security bill dealing with, among other items, airport security personnel.) But new regulations and technology can also enable existing screeners to do a better job. Reducing the number of carry-on bags allowed per passenger will enable each bag to receive closer scrutiny by screeners.

Twenty years ago, the FAA was supporting research into the use of gerbils as sniffers to detect explosives. Bag-screening technology has come a long way since then. Computed tomography—CT scanning— takes multiple X-rays of a bag to produce a three-dimensional image of its contents. Quantum Magnetics has produced a scanner that uses magnetic resonance imaging to search for hard-to-find explosives, such as plastic explosive rolled into a sheet and sewn into the side of a briefcase. The problem with these machines is their cost. The biggest scanner by InVision Technologies can handle up to 800 bags per hour, but each unit costs $1.5 million. According to Charles Barclay, president of the American Association of Airport Executives, the latest explosive detection systems are in service at only 46 airports across the country.

Perhaps the most problematic of security challenges is the screening of passengers. The FAA and Northwest Airlines developed the Computer-Assisted Passenger Pre-Screening System, which profiles passengers based on information in an airline's reservation system, such as if the ticket was puchased with cash or if the ticket is one-way. So far, though, CAPPS has been applied only to passengers who stop at an airline ticket counter, usually to check baggage, before proceeding through security.

There is also a need to ensure that the people who board airplanes are the same ones who bought the tickets and went through airport security checkpoints. One proposed security system would photograph all passengers with their checked luggage. Each photograph would be encrypted on the passenger's ticket in the form of a bar code.

BRIAN SNYDER/REUTERS NEWMEDIA INC./CORBIS

After September 11, security companies and the airlines that hire them have come under fire. Now there is agreement on the need to federalize or upgrade the screener workforce.

When the ticket is scanned by an airline agent at the boarding gate, the agent's computer monitor would display the photograph of the ticket-holder. If the two faces don't match, the traveler would be denied boarding. The same technology could also be used to match passengers with their bags, so that any unmatched bags could be removed from an aircraft prior to takeoff. The technology exists, but implementation will depend on approval by the FAA.

Airline travelers are now required to present a government-issued photo identification at the airport. A new company, Synaptek, is offering a system to make better use of that ID check. With a hand-held reader or desktop terminal, airline or security personnel would scan or enter data from passenger identifications. By encrypted communication, the device would then check to see if an individual is on any of a number of law enforcement or watch list databases. If such a system had been in place on September 11, some of the hijackings might have been thwarted, as some of the hijackers were on watch lists.

Passengers now face long lines at airports, but the NATA is sponsoring a system that could speed things up. Individuals would be pre-screened thoroughly for inclusion in a database of secure, trustworthy travelers. Then, like motorists who can pay tolls electronically and drive through without stopping, these travelers could quickly pass through special airport checkpoints. They would show they're in the database through a biometric check, such as iris recognition. James Coyne, NATA president, says, "Security screening is finding a needle in a haystack. This system lets you eliminate most of the hay, so you can look closely in the smaller pile that still has the needle."

Until recently, aviation security planning was largely reactive. A spate of hijackers who wanted to go to Cuba led to metal detectors and X-ray machines. Pan Am 103 prompted research, mostly still unimplemented, into bomb-hardened containers and cargo holds.

This time there seems to be an effort to anticipate threats. Honeywell, for example, is working on tamper-detection monitors for aircraft wiring. "We need to plug all the holes," says Honeywell spokesman Ron Crotty. "Shut one door and they'll look for another one that's open."

Ready Flap!

Birds do it, bees do it. Can two weird aircraft make aviation history doing it?

by Graham Chandler

Photographs by Phil Schofield

This is a story about two guys named Jim. Both were born in the 1940s, both grew up in the same neighborhood of Park Forest, a town on the south edge of Chicago, and both attended the same church, but neither knew about the other until one of those one-in-a-billion coincidences. They became acquainted through a seminar at the 1999 Experimental Aircraft Association fly-in at Oshkosh, Wisconsin, and discovered they were probably the two people in the world closest to achieving an aeronautical dream that has eluded humans since the dawn of time.

This morning I'm standing next to one of them, just outside a hangar at the decommissioned Royal Canadian Air Force Downsview base in Toronto. He's tall and straight, his name is James DeLaurier, and he is a professor at the University of Toronto's Institute for Aerospace Studies. Poised beside us is a little aircraft that may one day soon realize the dream of the two Jims, a craft affectionately known as Big Flapper. It is intended to fly not with propellers, not with jets, but with flapping wings.

For centuries, attempts at building airplanes were, naturally enough, based on the way birds fly. But coming up with the perfect wing proved extraordinarily complex. Now, with the help of microcomputers and composite materials, the dream of bird-like flight is being revisited.

This morning's run is a taxi test to feel out a redesigned undercarriage. Test pilot Patricia Jones-Bowman arrives at the hangar in a beat-up Buick. She has chestnut-red hair and wears wraparound sunglasses and a blue flying suit. An ex-bush pilot, she volunteered for the project after hearing about it from her dentist, a talented woodworker who had built jigs for the Flapper's wing spars. Craning her neck, she eyes Flapper's wings, which are poised in the up position, like the wings of a hummingbird in a strobe photo.

There's not a breath of wind in the gray dawn as she takes a few complicated minutes to settle her tiny frame into the cockpit. One of the crew chiefs, Derek Bilyk, signals "All clear," and she hits the start button. The tranquil air is cracked by a dirt-bike-exhaust note, which is backed by a whining,

Set

At the University of Toronto, Big Flapper is reaching for a first in aviation: flying by flapping.

"By far the ***biggest design challenge*** was the wing," shouts DeLaurier over the din. "I would say this wing is the most technologically complex wing in history—it's the first that has had to ***provide both thrust and lift."***

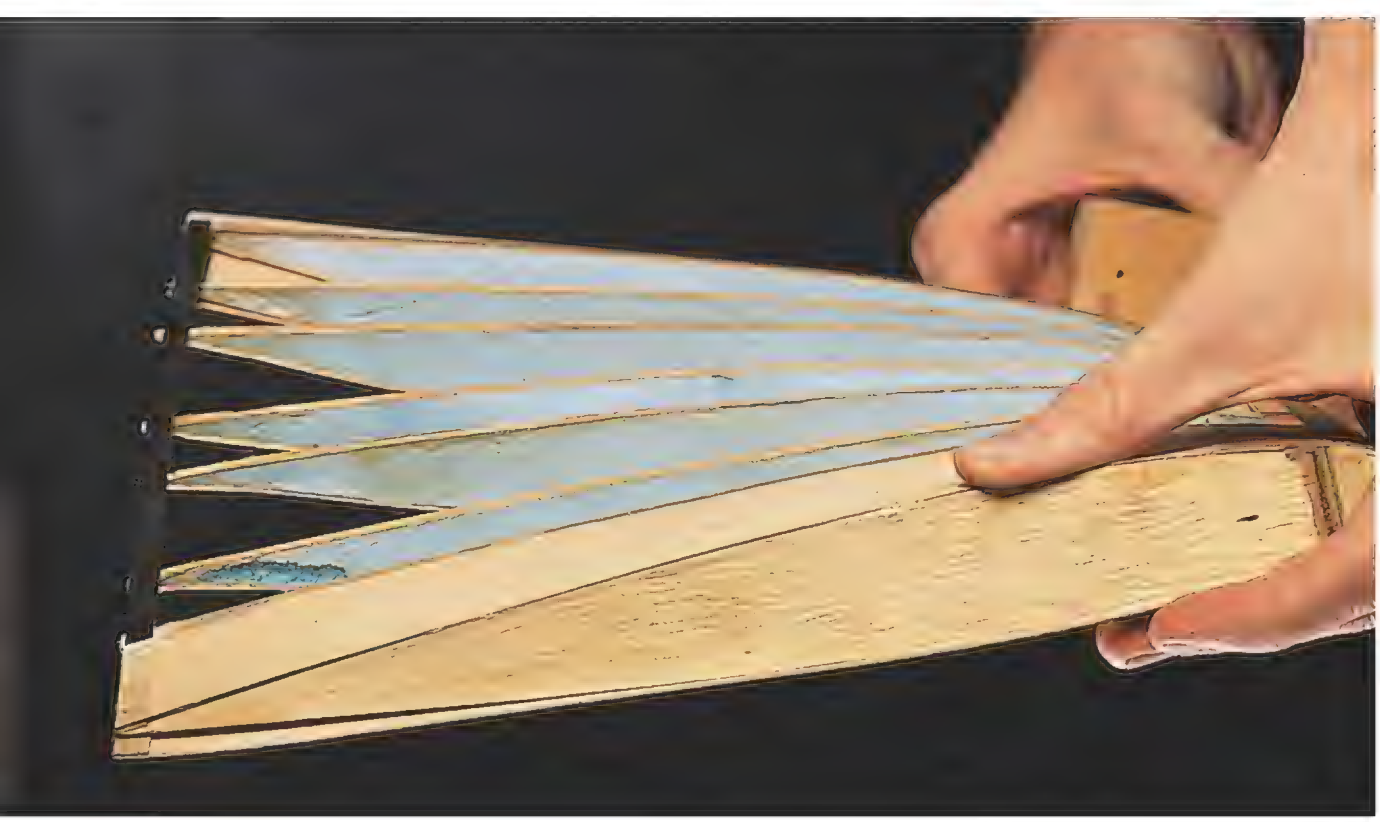
Crew members Derek Bilyk, Bruce Felton, and Jim DeLaurier (left to right) install a wing model in a wind tunnel for testing.

something like that produced by the windshield wipers of an old schoolbus: *rr-RR rr-RR rr-RR.* Big Flapper has awakened. It flaps its 41-foot wingspan like a giant rooster about to crow at the dawn. Its 24-horsepower two-stroke ultralight engine is coupled directly to the wings through a mechanical drive unit. A sprocket-and-chain mechanism drives two pylons, located just behind the pilot, up and down, raising and lowering the center sections of the three-section wings. At top engine performance, 3,800 rpm, the wings flap 1.3 times a second. But that's not achieved until the craft is on the runway. For this runup, 0.94 per second is about the maximum at which the bucking beast can be held down.

Big Flapper was built in 1996 but is the culmination of over three decades of research. DeLaurier's partner, Jerry Harris, who conceived Flapper and paid for its construction, recounts: "I first considered flapping flight in 1968, as an application for the mechanical power amplifier I was analyzing for my master's thesis at Ohio State University." He began collaborating with DeLaurier in their spare time while both were working at Battelle Memorial Institute in Columbus, Ohio, in 1973. "Natural or flapping flight was one of the very few areas still open to fundamental investigation and engineering analysis," says Harris. "Fundamental" is the critical word here; as far as practical applications go, there is little at present—a fact that appears to bother none of the team members.

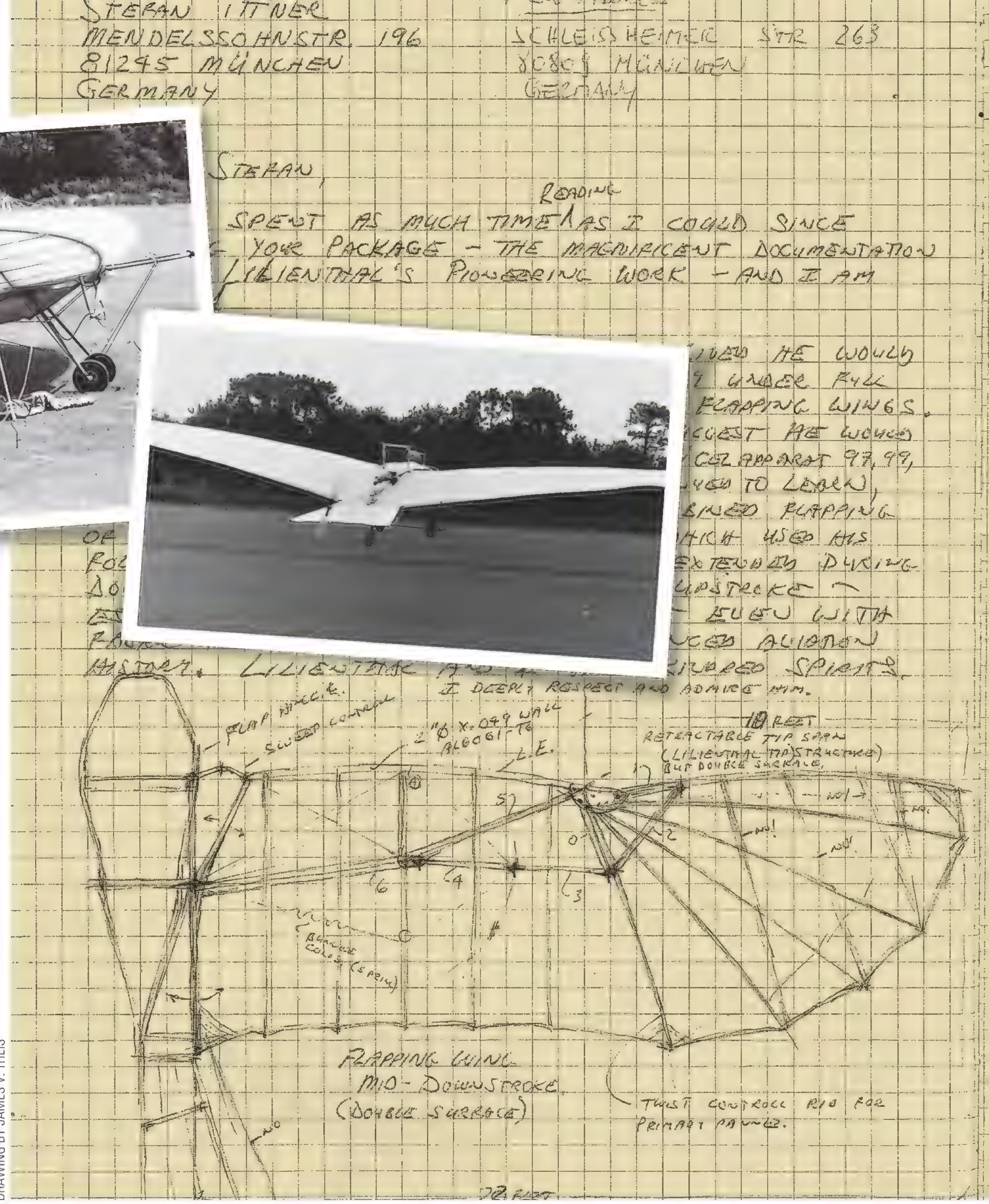
When DeLaurier accepted a position teaching aeronautical engineering at the University of Toronto in 1974, flapping-wing research did produce one practical offshoot of sorts: It gave some of DeLaurier's students a focus for study. Around a dozen senior and master's theses, as well as a doctoral dissertation, have helped design Big Flapper. And one student, Theresa Robinson, is doing a master's thesis on the use of ornithopters to explore in thin atmospheres like that of Mars. But theory and models can predict only so much. Flapping-wing flight today is akin to supersonic flight in the 1940s—an unknown regime where stability and control are only educated guesses. To find out what happens, you have to do it for real.

"By far the biggest design challenge was the wing," shouts DeLaurier over



A model of the Flapper wing, sans *fabric. The hands hold the leading edge, with ribs attached. The black strips at the other end are the two trailing edges, to which the pieces of wing fabric are attached. As the wing twists, the edges slide past each other, perpendicular to the ribs.*

COURTESY LINDA THEIS (2)



DRAWING BY JAMES V. THEIS

Above, left to right: Jim Theis' wife Linda and daughters Cindi and Pattie enjoy Nighthawk's shade (autumn 1978). Photo, right: Theis flying Nighthawk at a polo field. Drawing: Part of a letter by Theis showing the support structure for Nighthawk II's deformable wing.

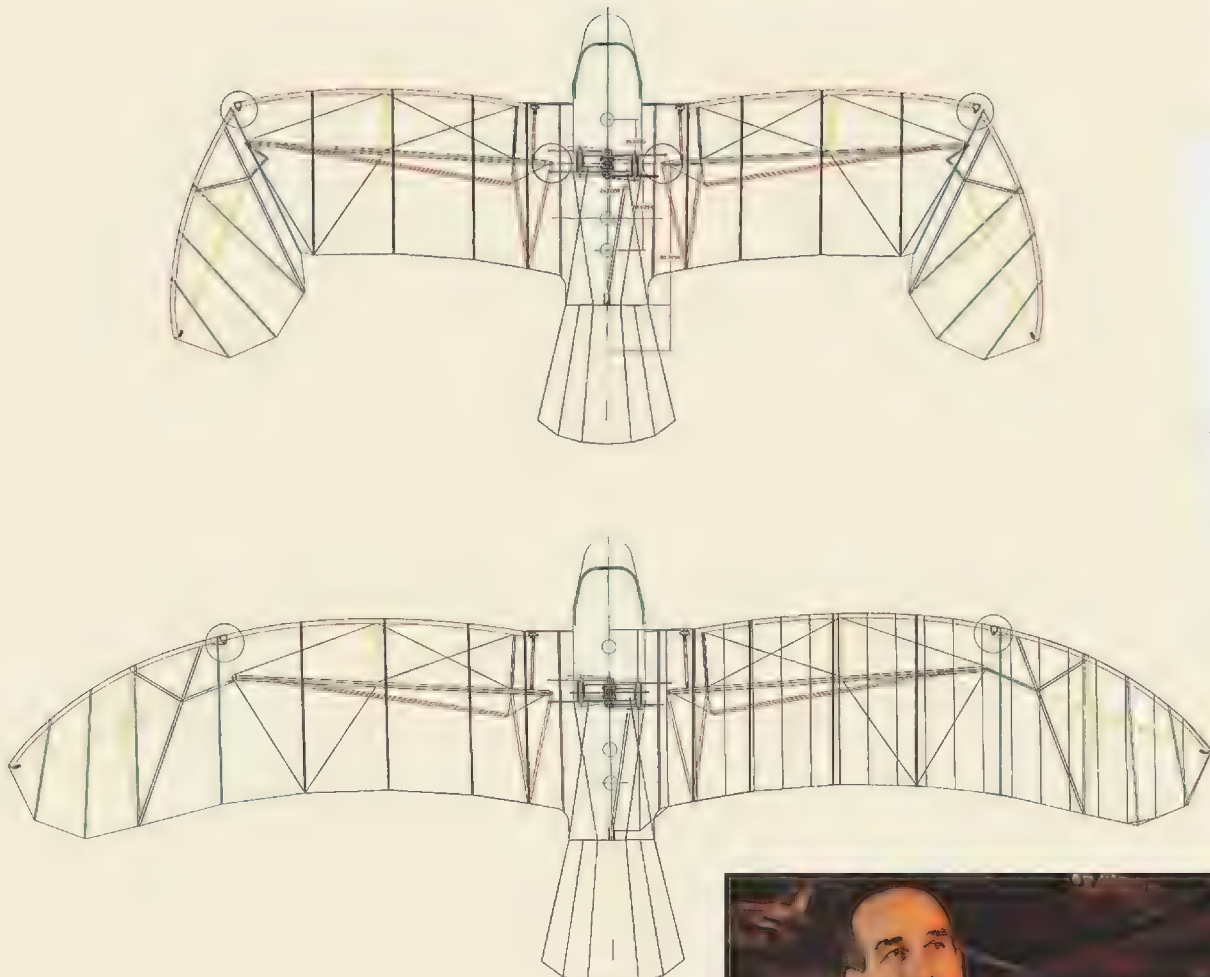
the din. "I would say this wing is the most technologically complex wing in history—it's the first that has had to provide both thrust and lift." Early on, DeLaurier and Harris studied film clips of bird flight in slow motion. "There were just too many different motions happening at once," DeLaurier recalls. "The thought of modeling it was intimidating." In designing Flapper, DeLaurier figured that it would be enough to produce a careful combination of flapping and twisting to generate lift and thrust. On the upstroke, the wing twists to a positive angle relative to the fuselage, and on the downstroke, it twists to a negative one. This provides the thrust necessary for forward flight. But achieving the optimum twist was no cakewalk. Either too much twist or too little would produce inadequate lift. In fact, too much twist would take energy out of the airstream and produce negative thrust—drag.

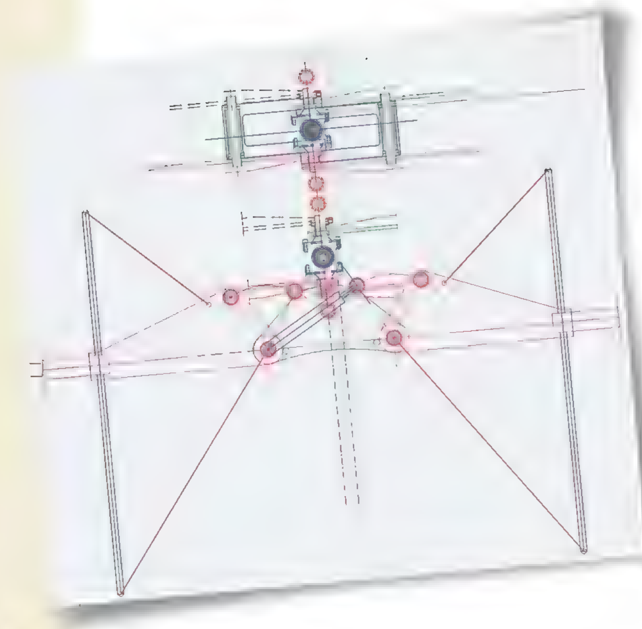
And while the wing is twisting, it also needs to maintain the right degree of bending rigidity. DeLaurier explains the concept by asking me to imagine holding the ends of a cardboard tube. "Try and twist it," he says, "and it remains rigid. But slit it down the length of one side and overlap the edges and you can twist it while it remains stiff." DeLaurier and Harris pulled off a similar innovation by conceiving a shear-flexing design. Each wing is composed of two flexing sections of polyester; during flapping the sections slide over the wing ribs. The sections are attached to what is essentially a double trailing edge: One section slides over the other, like the two edges of the cardboard tube.

Harris and DeLaurier first tested the concept with a 10-foot-span radio-controlled model they named "Mr. Bill" (after the misfortune-prone "Saturday Night Live" creation). It took years of research, they say, before Mr. Bill was able to fly with their shear-flexing design and demonstrate their method of three-axis control, which they later used in Big Flapper.

In the full-size ornithopter, the pilot controls pitch by manipulating the horizontal stabilizer. But the third function of a flapping wing, lateral control, hasn't been included on Flapper's wing. The shear-flexing wing design precludes the use of standard ailerons for direct roll control. So Flapper is designed to turn solely by rudder. The pilot will bank by a technique known as yaw-roll coupling. Lateral stick input deflects the rudder, yawing the aircraft. The windward wing experiences an increase in angle of attack and airspeed and therefore enhanced lift, which rolls the aircraft in the direction of the turn.

Flapper has yet to demonstrate that it can actually do any of this. During a test in November 1998, as Flapper exceeded 50 mph, it started to lift off the runway, then smacked down on the ground so hard that the nose gear failed. To keep the craft on the runway while the speed increased, the team shortened the nose gear so Flapper had a nose-down angle. That suppressed lift buildup. "What we hadn't acccounted for," says DeLaurier, "was that the new





DRAWINGS BY JAMES V. THEIS

Above left: Computer-aided design shows Nighthawk II's wing articulation, retracted (top) and extended. Above: Two views of the hydraulic system Theis and Brian Said created to drive the flapping. Below left: Said holds a model of the Nighthawk's articulating wing spar.

CAMERON DAVIDSON

down force from the wings was imposing compressive loads in our vertical struts beyond the design limit." During another test, this one in October 1999, Jones-Bowman reached 56 mph—just short of Flapper's predicted 57-mph takeoff speed—when one of the vertical struts buckled. The team reinforced the struts.

Once we get clearance from the tower, Jones-Bowman comes up on the throttle and Flapper beats its wings down the runway. Taking their cues from the rhythm of the wings, the fuselage pulsates up and down, the tail takes little dips, the main gear does mini-squats, and the wing supports flex. The cadence picks up as Jones-Bowman accelerates to 35 mph, turns around, and does it again. We're in formation at her two o'clock, sitting in the back of a rusty VW pickup, when Flapper's engine sputters and dies.

The crew pushes Flapper off the active runway. After 20 minutes, the problem is declared to be a blockage in the fuel filter. An engine failure in flight has been thought of, and DeLaurier calculates that wing loading—essentially, the difference between the pressure of the air above the wing and that below it—would overcome the engine compression and drive the wings to their full-up position. "Lateral control would be pretty sensitive with all that dihedral," he says. "But with small and tender inputs, it would be flyable."

By now the wind is picking up. Since sideslipping into a crosswind without both aileron and rudder is dicey, testing the aileron-less Flapper is best done in calm, limp-windsock mornings, so testing is called off for the day.

I ask Jones-Bowman how it feels to be inside Big Flapper. "I'm steering, controlling, bouncing, watching instruments and everything," she says. "Once I rev up, it's up and forward, down and backward, and the stick goes with me. I tell myself not to try and stop it but it's difficult. If I do, PIOs are gonna be a problem." ("PIOs" are pilot-induced oscillations—the pilot's attempts to correct pitching motions actually increase their amplitude, rather than diminish them.)

A few months following my interview, Jones-Bowman resigned as project test pilot, citing safety concerns related to the liftoff incident. Jack Sanderson, a longtime ultralight and homebuilt enthusiast, jumped at the chance to replace her. "I had to go on a crash diet," he says. "But once I got in the cockpit it felt natural."

Near the start of his project, DeLaurier had heard that other attempts were under way to make the first flapping-wing flight. But he never met the other Jim until one of his students attended a Flapping Forum at the 1999 Oshkosh fly-in and heard Jim Theis talk about his project. The following May, the two Jims got together at Zumbrota, Minnesota, where Theis' ornithopter project, Nighthawk, lay in parts. After that meeting, Theis and project partner Brian Said, perhaps inspired by Big Flapper (or by the thought of Flapper beating Nighthawk), accelerated their efforts to make the first ornithopter flight. By late October they had finalized a plan to fly within a year. Things were well under way when Theis died last January. "Jim Theis was one of the most innovative researchers I've ever met," DeLaurier says today. "If our respective design approaches hadn't been so far along, I'm sure that we would have collaborated." The Nighthawk project is now in the hands of Brian Said.

For hundreds of miles along all the Ocean Boulevards of Florida's Atlantic coast, pelicans enjoy catching ocean breezes, using the occasional flap of a wing to correct for gusts or to gain a little altitude. Brian Said lives here with his wife Winnie, in a palm-shaded house near the Jupiter Inlet, and he envisions human beings delighting in the same sort of flying. The deep-

As far as *practical applications* go, flapping flight has few at present—a fact that appears to bother *none of the team members.*

JAMES WINFIELD/GETTY IMAGES

"Mr. Bill," a radio-controlled proof-of-concept model, helped Harris and DeLaurier develop their shear-flexing wing design and flight control innovations.

thinking engineer is surrounded by waist-high stacks of logbooks and the da Vinci-esque sketches of Jim Theis, whom he met in 1976 at Florida Atlantic University.

Said's ornithopter design philosophy differs from DeLaurier's. He wants to fly more like birds: control flapping angles and rates, no vertical tail, soar when the currents are right, turn with wing warping rather than yaw-roll coupling to a vertical rudder.

Without Theis, Said has more to do than DeLaurier and Harris. The original Nighthawk, built more than 20 years ago, was not an ornithopter—it had no flapping-wing drive—but rather a smaller-than-average ultralight with a pusher prop. It was designed to prove the team's system for lateral control. Said explains that in the wing warping that the Wright brothers used for lateral control, the warping was coupled—when one wing warped, the other warped in the opposite direction. That produces adverse yaw, he says, and that's why the Wrights had to add a vertical stabilizer. Then Said pulls out a case of video tapes to demonstrate his and Theis' alternative—"independent reverse wing warp."

We watch scenes reminiscent of early black-and-white movies of flight. In them, Theis lays prone in Nighthawk I's cocoon-like cockpit, gets airborne to roughly 10 or 12 feet at about the speed of a man running, and flies back and forth across a field, turning at each end like a bird. There's no vertical stabilizer or rudder, just a separately controlled pigeon-like tail that moves up-down, left-right, and twists around its long axis, plus wings that "reverse warp" independently. "With independent reverse wing warp," Said explains, "when you want to make a right turn, the right wing is twisted to a more positive angle." That increases the angle of attack, and therefore the lift and drag, on the right wing, which, when coordinated with tail inputs, turns the aircraft to the right. The movement is similar to the way a bird turns while soaring, deflecting airflow to one side or the other by adopting asymmetrical wing positions and twisting its tail. Said says there's no adverse yaw.

Testing progressed nicely until 1979, when, on a final test run over a polo field late in the day with low visibility, Theis pulled up over a scoreboard. On the other side was a speaker post; one wing struck it, and Nighthawk rolled over, slamming Theis into the ground. His back broken, he spent the rest of his life in a wheelchair. "Jim was undaunted, but [the accident] set back our program," says Said.

For the next 20 years Theis and Said dabbled with designs for a flapping-wing version of Nighthawk, but earning a living took priority (Theis had his own engineering design firm, and Said is an engineer at Lockheed) and the project languished. That is, until the visit by DeLaurier. "After that we sat down and got our heads together seriously for a solid month—the longest sustained effort yet," says Said. Using Nighthawk's wing, Theis worked into the night completing all stress and performance analyses and computer-simulated lift and thrust curves. He and Said perfected a design for a flapping drive mechanism powered by hydraulic actuators. "It was a real light bulb for me," says Said, who likes hydraulics because they enable the pilot to exert direct control over flapping angles and rates, with micro-computers used to regulate response to control inputs. "The actuator is designed for a high repetition rate and high fatigue tolerance," he says.

But research needs to be funded. "We hadn't actively sought external funding," says Said. For now, funding is split between Said and the Theis family, supplemented by donations of parts and materials from corporations.

Said is in the process of transporting the Nighthawk project from Theis' Minnesota home to Florida. Then he will install the flapping wing drive unit and press on toward a first flapping flight. He is looking for funding to accelerate the effort. The Theis family name may stay with it: Jim's son Charlie is a Delta Air Lines pilot, and he says he'd love to fly it.

Will humans ever produce a workable technology for flapping-wing flight, or is it really just for the birds? "It may or may not make sense to extend it to machines," says DeLaurier partner Jerry Harris, "but people are compelled to try."

How Things Work: Cabin Pr

by George C. Larson | Illustrations by John MacNeill

We humans need air to live, so we do best around sea level. Airplanes are at their best up high, where the air is thin and smooth. And therein lies the rub: We invented a machine that thrives where we don't. This became obvious as soon as engine power increased to a point at which aviators could reach altitudes where they lost consciousness.

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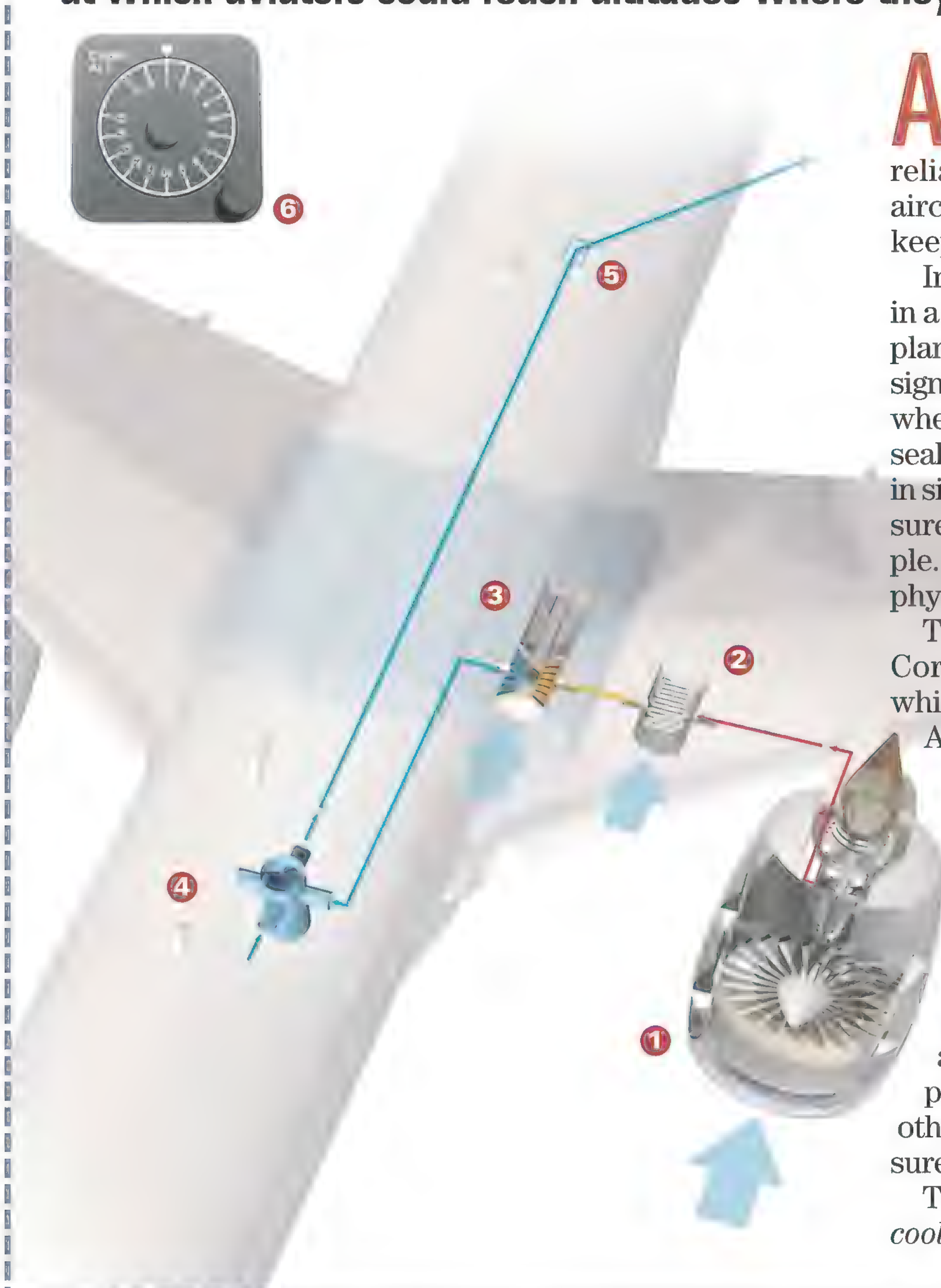

At first, fliers coped by filling tanks with pressurized oxygen and inhaling the gas through rubber tubes; later, form-fitting face masks made oxygen delivery more reliable. In many high-flying light airplanes and military aircraft, oxygen systems and face masks are still used to keep the pilot alive and conscious.

In 1937, the U.S. Army Air Corps began research flights in a modified Lockheed Electra; the XC-35 was the first airplane built with a pressurized cabin. The fuselage was designed with a circular cross-section to eliminate stress points when the fuselage expanded under pressure. Openings were sealed to prevent air from escaping. Windows were reduced in size and strengthened, and the cabin inside became a pressure capsule—like a big aluminum can—that held five people. In 1937, the XC-35 earned the Air Corps the Collier Trophy for most significant development of the year.

Two years later, Boeing submitted a design to the Air Corps for a long-range bomber, the B-29 Superfortress, which would have pressurized compartments for the crew. And in 1940, Boeing's 307 Stratoliner began flying passengers in pressurized comfort at 20,000 feet. Today all airliners are pressurized, and although the details vary among them, the basic elements of cabin pressurization systems are almost universal.

Air is pressurized by the engines. Turbofan engines compress intake air with a series of vaned rotors right behind the fan. At each stage of compression, the air gets hotter, and at the point where the heat and pressure are highest, some air is diverted ❶. Some of the hot, high-pressure air, called *bleed air*, is sent to de-ice wings and other surfaces, some goes to systems operated by air pressure, and some starts its journey to the cabin.

The cabin-bound air has to be cooled first in an *intercooler*, a device like a car radiator that sheds the heat to

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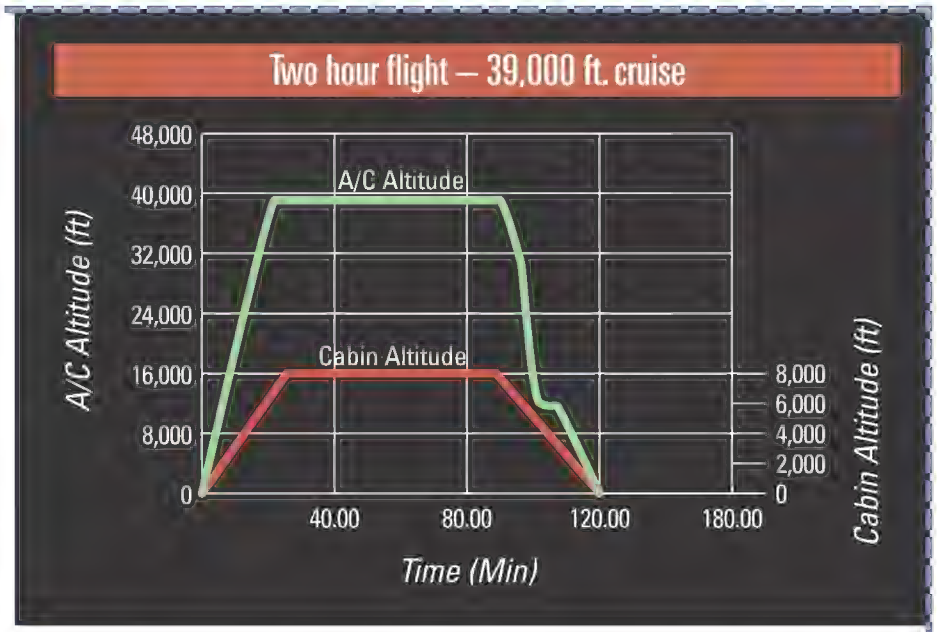
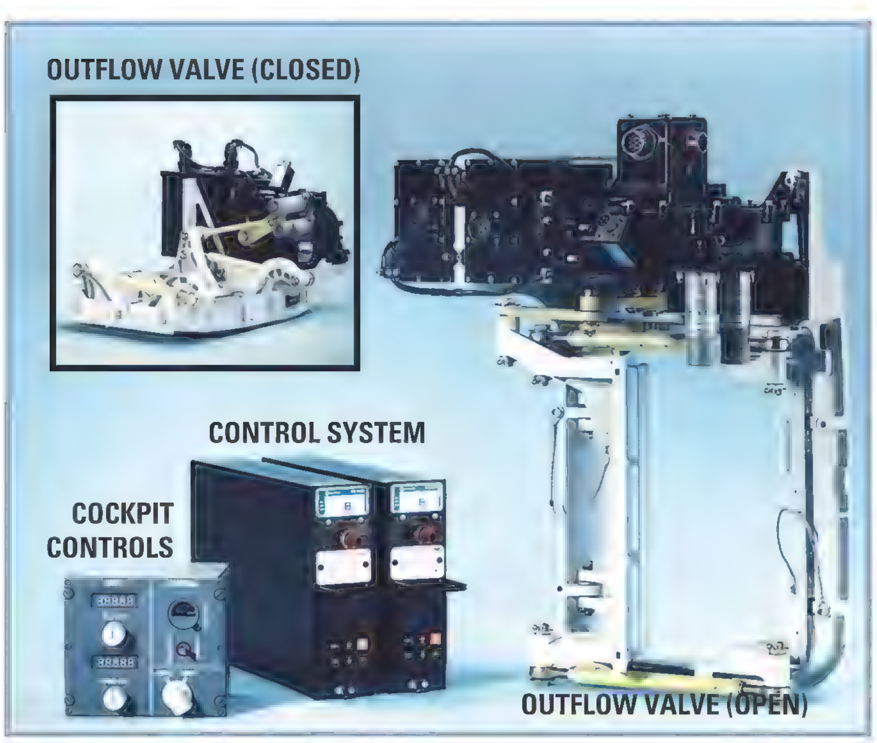


the ambient air scooped aboard for that purpose ❷. From there the air travels into the airplane's belly, where *air packs* cool it further using air cycle refrigeration ❸. An air cycle cooler is perhaps the simplest air conditioner ever invented, because it doesn't need a refrigerant as an intermediate fluid to dump heat. The air packs compress the incoming air to heat it before sending it to another intercooler to dump the heat to the outside. The air then expands through an expansion turbine, which cools it the way blowing with your lips pursed results in a cool flow of air. (Test the principle by blowing with your mouth wide open to see how warm the air would be if it weren't compressed and then allowed to expand.)

Now the air is ready to mix with air from the cabin in a mixer, or *manifold*, ❹ that adds the new air to the recirculating cabin air, which is moved by fans. To maintain a comfortable temperature for the passengers, automatic systems regulate the mixture of heat from the engines and cold from the air packs. To maintain the pressure in the cabin equal to that at low altitude, even while the airplane is at 30,000 feet, the incoming air is held within the cabin by opening and closing an *outflow valve*, ❺ which releases the incoming air at a rate regulated by pressure sensors. Think of a pressurized cabin as a balloon that has a leak but is being inflated continuously.

On the ground, the airplane is unpressurized and the outflow valve is wide open. During preflight, the pilot sets the cruise altitude on a *cabin pressure controller* ❻. As soon as the weight is off the main wheels at takeoff, the outflow valve begins to close and the cabin starts to pressurize. The airplane may be climbing at thousands of feet per minute, but inside the cabin, the rate of "climb" is approximately what you might experience driving up a hill. It might take an average airliner about 20 minutes to reach a cruise altitude of, say, 35,000 feet, at which point the pressurization system might maintain the cabin at the pressure you'd experience at 7,000 feet: about 11 pounds per square inch. Your ears may pop, but the effect is mild because the climb rate is only 350 feet per minute. When the airplane descends, the pilot sets the system controller to the altitude of the destination airport, and the process works in reverse.



HAMILTON SUNDSTRAND

The structural strength of the airplane determines how much differential pressure the cabin can tolerate—a typical figure is eight pounds per square inch—and the fuselages of new airplane designs are pressurized and depressurized many thousands of times during testing to ensure their integrity. The higher the maximum differential pressure, the closer to sea level the system can maintain the cabin. Federal Aviation Regulations say that without pressurization, pilots begin to need oxygen when they fly above 12,500 feet for more than 30 minutes, and passengers have to use it continuously above 15,000. On airliners that operate at altitudes well above that, regulations require that everyone aboard be supplied with 10 minutes of oxygen in the event the cabin pressure can't be maintained, which brings us to the dramatic scenario known as *explosive decompression*.

If the door blew off a jet at altitude, all the air in the cabin would depart very quickly and a momentary thick fog would envelope the cabin as the water vapor in the air condensed instantly. Loose articles would fly around and foam rubber would burst as the tiny air bubbles within it expanded. Within a couple of seconds, oxygen masks would drop down from the overhead panels, and you would have to pull yours toward you and place it over your mouth and nose. The act of donning the mask tugs on a lanyard that starts the flow of life-sustaining oxygen.

If you've been following news reports and have heard that more armed air marshals are flying these days and that a stray bullet would cause decompression, you can stop worrying. The airplane already has a huge hole in it called the outflow valve. And air marshals are reputed to be excellent marksmen.

SCIENCE FLOATS

What a satellite can do, balloons will do cheaper.

by T.A. Heppenheimer *Photographs by Chad Slattery*

Two in the morning in eastern New Mexico. About 20 people have gathered at an abandoned World War II bomber training base. There's nothing here except leftover hangars. Grass grows through cracks in the pavement. Visitors are warned of rattlesnakes. On the steel siding of one building, the letters "N A S A" have been painted. The building serves as a weather station and payload preparation facility for scientists who send instruments to the very top of the atmosphere by hitching them to giant balloons.

On this warm spring night, an X-ray telescope is ready for flight. A windsock dangles vertically, showing what looks like dead calm, but since the balloon with its payload will stand nearly 900 feet tall when released—by comparison, the Washington Monument is only 565 feet—surface calm is just one of the weather conditions necessary for a launch.

A technician releases a small rubber test balloon, some two feet across and inflated with helium. It rises rapidly on a cord, like a fish pulling a line, and reaches an altitude of a thousand feet, at which point it pulls its tether to a noticeable angle. The "piball," or pilot balloon, is showing winds aloft. A second piball, tracked with a theodolite—a small telescope linked to a computer—reports winds up there as high as 35 mph. Launch director Erich Klein cancels the attempt, and the small group disperses.

This is par for the course for NASA's balloon people, the meteorologists and launch crews of the National Scientific Balloon Facility, a government-owned, contractor-operated organization that launches approximately 20 science payloads a year from here in Ft. Sumner, New Mexico, as well as from its headquarters in Palestine, Texas, and launch pads in Canada, Australia, and Antarctica. "I've seen it take a month to get off one balloon," grumbles astronomer Jonathan Grindlay of the Harvard-Smithsonian Center for Astrophysics in Massachusetts. Grindlay, this morning's launch customer, needs to get his telescope to 128,000 feet in order for it to detect X-rays in the upper atmosphere. He is testing the effectiveness of two X-ray instruments.

Klein and his crew take the waiting in stride. "You learn to be patient," he says. "It does get frustrating. Sometimes we wait for weeks. But eventually, a week can turn everything around."

Launching balloons has grown more demanding over the years. Much of the early work took place at Palestine, but around 1990 there was a significant expansion. New sites for launches were developed in Australia, Antarctica, and Canada, and the launch crews had to be willing to travel to those places.

"We went through a difficult transition," NSBF site manager Danny Ball recalls. "It took several years for guys to say, 'I just can't do this anymore.' So when one of those guys would leave, we'd bring in another person and explain very carefully that part of his job would be to go on the road three to five months out of the year.

"It took several years to get the crew we've got today," he continues. "People who don't mind the travel, who are really interested in the work."

At any of the locations, the launch

Opposite: Your launch vehicle awaits. Giant balloons can lift four-ton loads to the edge of space. Right: Glenn Rosenberger prepares a piball to test the wind.

crews are constantly at the mercy of the weather. Senior meteorologist Glenn Rosenberger, who has been helping launch balloons for almost 50 years, uses five different mathematical models to predict weather, and he says they sometimes give him five different answers. In that case, he says, he consults with his colleagues, who may disagree with his conclusions. In the end Rosenberger relies on his many years of experience to decide which prediction to trust.

Whatever the predictions, balloons can't be launched in anything but a calm. The team members sometimes get dispirited when they have a run of bad weather, says Klein, but when the weather turns favorable, "you can get two off in three or four days. Then the world looks a lot brighter. Before then it's, 'Oh, I'm never going to go home.' [Then] boom, you get one off and you see the light at the end of the tunnel.

"There are a couple of other balloon programs in the world," he continues, "but we are the best. We fly the biggest balloons, the heaviest payloads, for the longest durations at the highest altitudes. It's an incredible high when you get one off."

The scientists have a different perspective. Jonathan Grindlay describes the long waits for a launch as "painful." "You're not able to do as much with your finite grant dollars," he says.

Fortunately, it didn't take a month to get Grindlay's X-ray telescopes in the sky over Ft. Sumner. Less than a week after the first attempt, the telescope, which weighed 4,800 pounds, made it up. "High-altitude winds blew it to the east, toward Texas," NASA manager Steve Smith recounts. "Then those winds changed and blew it to the west. It crossed Interstate 25 toward evening, in clear sky and at very high altitude. A lot of people saw it and started making phone calls. They thought they were seeing a UFO from Roswell."

For Grindlay, the launch was worth the wait. His team was able to evaluate the properties of a small prototype X-ray detector, and a larger instrument provided spectra for further study of the well-known X-ray source Cygnus X-1. And the launch, supported by the Astronomy and Physics Division of NASA's Office of Space Science, cost

Big payloads need big parachutes. A recovery team retrieves a balloon-launched instrument package (not shown) and prepares to fold its ride.

Letting Go

The first step in launching a science balloon is to find a remote area with plenty of room in case the launch vehicle springs a leak. The main balloon base of the National Scientific Balloon Facility is near Palestine, Texas, in pine and farm country southeast of Dallas. The closest neighbors are prisons; a road sign warns motorists that hitchhikers may be escaping convicts.

Launching a balloon can take no more than part of a morning, if the winds are sufficiently gentle. The operator of a mobile crane, which the launch crew has nicknamed Tiny Tim, lifts a long steel boom, to which the payload has been attached. With the payload dangling, Tiny Tim trundles over to the center of the launch area, a circle of blacktop a thousand feet across. Opposite the direction of the breeze, members of the launch crew lay down a long strip of canvas to protect the balloon from damage. They extend canvas beyond the asphalt and across a field of mown grass, disturbing an audience of grasshoppers. At the edge of the field a semi awaits with an 80,000-pound load of cylinders filled with compressed helium.

The 20 people in the launch crew, mostly in their 30s and early 40s, all wear white hard hats. One man has decorated his with plastic Viking horns. "It's for luck," he says. "We always get a good launch when I wear them." Members of the crew talk quietly as they work, using walkie-talkies to stay in touch with the control tower.

The white spool will gradually feed out plastic as the balloon inflates.

Laid on protective ground cloth, the balloon is ready...

The balloon, folded tightly in a large wooden box, arrives on a trailer pulled by a pickup truck. It takes four people to lift the

balloon from the box and unfold it into a long strip of polyethylene, still folded lengthwise and protected by a red wrap. When it's stretched to its full length, technicians attach a parachute; the other end of the parachute is attached to the payload, which has thick pads of corrugated cardboard to cushion its impact when it lands.

...for attachment to an 8,900-pound payload, waiting on a mobile crane.

With a loud hiss, helium begins to flow from the canisters through metal sleeves and into long plastic tubes feeding the balloon's upper area. Slowly the top of the balloon takes the shape of an inverted teardrop. Most of the balloon continues to lie along the canvas until the rising action of the helium-filled end of the balloon releases it from a restraint. The filled end rises and pulls the rest of the balloon's length upward, then lifts the parachute as well. The payload is still attached to the mobile crane; its operator watches for any breeze that will waft the helium-filled teardrop overhead. Then, with his diesel engine rumbling, he drives slowly across the pavement, following the direction of the wind and keeping the balloon directly overhead. When he is satisfied that the balloon has taken up the weight of the payload, he releases it. There is no countdown and no turning back.

Helium flows from trucks to balloon, now a fraction of its eventual size.

Immediately after liftoff, the balloon typically rises at several hundred feet per minute. Still, it seems to hang in the air. While scientists in the hangar follow the data that now is beginning to come in, other specialists head for the control tower, where they will track the balloon during the next several hours.

less than $200,000. The balloon, a standard 40-million-cubic-foot model, cost about $120,000, plus another $12,000 for the helium to fill it. The cost of payload integration and launch services, about $25,000, was also absorbed by NASA, as part of the operating costs of the agency's National Scientific Balloon Facility.

Had Grindlay launched his payload on a Delta II rocket, it would have cost between $40 and $50 million for the service. Yes, the payload would have orbited and returned data for years, as opposed to hours. But the low cost of a balloon launch places it well within the budget of university research groups of modest size, and recently, a few noteworthy discoveries made by such groups suggest that scientists look again at the humblest of launch vehicles.

Not only is a balloon cheap to launch, the culture of balloon science encourages thriftiness in the assembly of payloads as well. One researcher avoided paying $30,000 for a space-rated video camera and used an ordinary $200 security camera, relying on bathtub caulking when he needed additional electrical insulation. A gamma-ray telescope built by a team at the California Institute of Technology in Pasadena used home-movie video cameras to store data during the flight. One group of scientists, needing to protect photomultiplier tubes from stray light, fashioned shields from beer cans.

At Raven Industries, a balloon manufacturer in Sulphur Springs, Texas, senior engineer Mike Smith points out that in the world of balloons, "you don't see clean rooms. The instruments are built by guys wearing T-shirts and jeans. Probably every NASA flight has plywood as part of its payload," rather than the titanium honeycomb or similarly exotic materials used in satellites.

According to Mike Zimmerman, Raven's chief of quality control, payloads can also be cheaper because balloons can carry odd shapes that would have to be folded to fit onto a rocket, then unfolded in space. With balloons, he says, "you can have solar panels sticking out. You don't have to withstand G-loads" or the strong vibrations of a rocket launch. Designers avoid costly test programs, since they don't have to demonstrate that their instruments can withstand such forces. In fact, balloons have served as test platforms for instruments that were later space-rated and flown on satellites.

Balloon launches require wide, open spaces. In New Mexico, a balloon receives helium through transparent umbilicals.

The Compton Gamma Ray Observatory, one of NASA's premier astronomical satellites, is one that benefited from balloon tests. The satellite helped astrophysicists learn about violent events occurring near quasars, neutron stars, black holes, and supernovae, or exploding stars. Such events produce gamma rays and X-rays, which the orbiting observatory was able to detect. "Every instrument on the Compton was first developed on a balloon," says Jonathan Grindlay.

Yet for all their usefulness, balloons have an ongoing problem: They don't stay up very long. Most flights last between 12 and 24 hours. Those launched from Ft. Sumner are not allowed to cross the Colorado River, the state line of California, because they would pose hazards to air traffic if they descended near Los Angeles. Those launched from the National Scientific Balloon Facility's main base in Palestine, Texas, must come down before they cross the border of Mexico, only a few hundred miles away, because that country will not allow overflights. Ground controllers send a radio command to release the payload and its parachute if winds carry it toward the border. That action tears the balloon, which, venting helium, descends. Even balloons that fly in Australia, crossing the Outback and the Indian Ocean, stay up no more than a few days.

When borders aren't the problem, the duration of a balloon flight is limited by physics.

As a balloon rises, its helium expands. By the time it reaches its targeted altitude—in excess of 22 miles—the gas has expanded to fill the volume of the balloon, typically 40 million cubic feet. (The National Scientific Balloon Facility Web site notes that you could fit two Boeing 747s back to back inside the envelope.) The balloon has enough lift to rise still higher; however, it can expand no more and would burst if it continued to ascend. To prevent that, polyethylene tubes serve as vents, permitting surplus helium to escape. The excess lift vanishes, and the balloon flies near the desired altitude.

Then night falls. The balloon cools, contracts in volume, and sinks. To prevent it from descending, ground controllers send a command to drop ballast. When the sunlight of the following morning warms it anew, it rises again—and because it has dropped ballast and

Assembling a Giant

Raven Industries, a maker of balloons of all types, including many that fly in the Macy's Thanksgiving Day parade, assembles the giants that carry science instruments to altitudes of 25 miles. The balloons are made in a building just off Interstate 30, about 80 miles east of Dallas. Inside, the work area is nearly a thousand feet long, with rows of tables stretching end to end. On the tables are the long gores, or segments, that form a science balloon. The largest use nearly a million square feet—20 acres—of polyethylene film, less than a thousandth of an inch thick.

A Raven Industries technician runs the polyethylene dispenser.

Mike Zimmerman, Raven's chief of quality control, says, "We inspect every inch." Before the balloon is assembled, an inspector scans the film with polarized light to check for holes or weaknesses. Push your thumb into a sample of film; the dent is not easily seen. Yet it shows up clearly under the light.

A balloon of 40 million cubic feet has 172 gores and takes about three weeks to assemble. Raven's workers unroll sheets of polyethylene film, which comes folded lengthwise in rolls 54 inches wide, down the length of a table. They then run a sealing machine down the edges where two gores join; the machine uses heat to fuse the film and form gas-tight seams. The panels are cut along a curve, marked on the work tables with tape. As workers join the gores, they install load-bearing tapes that run the length of the balloon. The balloon stays folded during construction and prior to launch. It expands to full size only at altitude.

Raven builds about 20 balloons a year. Most of their instrument packages tip the scales at a ton and more.

In polarized light, "yielded" spots become visible.

therefore lost weight, it vents still more helium. Such cycles can continue only as long as the balloon has ballast. Once the ballast is gone, it descends for good.

If there were a way to interrupt the warming-and-cooling cycle, a balloon flight could last longer. One alternative is to travel to a place where the sun never sets. For the past 10 years, NASA's balloonists have launched from a base in Antarctica, where during the south polar summer the sun shines continuously. The balloons stay aloft for as long as two weeks, and several years ago, one of these longer flights produced headlines.

Just after Christmas in 1998, a mission known as Boomerang (for "Balloon Observations of Millimetric Extragalactic Radiation and Geophysics"!) was launched from Williams Field, six miles from McMurdo Station in Antarctica. Boomerang was intended to further the work begun by the Cosmic Background Explorer satellite, which in 1992 made historic observations (with instruments first tested on balloons) of the microwaves that fill all space with a thin electronic fog, the faint remnant of the Big Bang. COBE measured very slight differences in temperature—variations as small as 0.0001 degree—among various parts of the sky. Boomerang provided a finer measure, with high enough resolution to show the size of the "hot" and "cold" patches on the sky. According to Andrew Langeof the California Institute of Technology, one of the chief investigators on the project, "The Boomerang map shows structures that are the right size to have evolved into galactic superclusters, so for the first time there's a visible link between the embryonic universe and the present universe." The measurements also support a leading theory of the origin of the universe (see "The Big Push," below).

"This was a real high point in balloon science," recalls Grindlay. "It made the cover of *Nature*." (That, for scientists, is what making the cover of

Eventually, Ultra Long Duration Balloons (shown in an artist's conception) will carry science instruments on 100-day flights. Until then, the behemoths of the National Scientific Balloon Facility—the assembly is 900 feet long (opposite)—can offer shorter rides.

NASA

The Big Push

Minute variations in the temperature of the very early cosmos, mapped by Boomerang in 1999, support a theory known as inflation. Inflation theorists assert that in the course of the Big Bang, there was an inconceivably rapid expansion, during which the universe grew from a size a trillion times smaller than a proton to that of a grapefruit in less than 10^{-32} second.

Astrophysicists find this scenario compelling, for it predicts a universe with features that match observations: among them, uniformity over the universe's vast expanse. In an article about the Boomerang project, investigator Andrew Lange explains: "[T]he microwave background can be the same temperature everywhere because, before the universe inflated, all its parts were in very close contact and would naturally equilibrate to the same temperature."

But even in this uniformity—the temperature of the microwave background over the entire universe is 2.73 degrees Kelvin (above absolute zero)—there is variation on a very small scale. In one patch of sky, the temperature of the microwave background may be 2.7281, while in another patch of sky, it turns out to be 2.7283. Inflation theorists believe that these "hot" and "cold" patches are traces of quantum fluctuations in the pre-inflationary universe and, as such, are also proof of instantaneous expansion.

The laws of quantum mechanics recognize that a small amount of energy is always present, even in empty space. Quantum fluctuations are jiggles in this background energy. (Evidence for the energy's existence was found in laboratory experiments in which closely spaced metal plates were found to be pushed together by a quantum force.)

The process by which quantum fluctuations wink in and out of existence occurs at the speed of light and over a distance of 10^{-33} centimeters, known as the Planck length, for the German physicist who identified it. Had the universe expanded at the speed envisioned in the standard Big Bang theory, the expansion would have been far too slow for any trace of the quantum fluctuations to exist today. But according to the inflation theory, space itself expanded at a rate enormously faster than the speed of light. Inflation acted like stop-action photography, freezing the fluctuations in mid-jiggle, and at the same time, blowing them up from the "Planck length" to a macroscopic scale. At their post-inflationary size the fluctuations were no longer quantum—they now behaved according to the rules of classical physics. They took on the character of seismic waves within a universe filled with plasma, or ionized gas.

For the next 15 billion years, the universe expanded and cooled. Had observers been present when the cosmos was about 500,000 years old, and had they looked back toward its infancy, they would have seen these seismic features in optical wavelengths. Today the energy from the early universe has stretched into longer wavelengths, and the seismic features appear as the minute temperature variations in the cosmic microwave background.

Rolling Stone is for rock musicians.)

One reason that Boomerang could produce such phenomenal results is that it stayed up for 10 days. Moreover, Boomerang, appropriately enough, returned almost to its starting point because of circumpolar winds that stay nearly constant in latitude. Boomerang remained at or near 79 degrees south and traveled 5,000 miles. A radio signal then brought it down within 30 miles of its launch site.

If momentous discoveries can be had from a 10-day balloon mission, imagine what scientists could do with a balloon that stays aloft 10 times that long. NASA's balloon program office is at work on a new science balloon that could fly as long as 100 days. The Ultra Long Duration Balloon would be the first real alternative to satellites.

The ULDB is sealed and does not vent helium. The envelopes of conventional balloons are too delicate to withstand the pressure of expanding helium, but the ULDB is designed to be stronger. Mike Smith of Raven Industries, which is assembling ULDBs, explains that instead of expanding in sunlight and contracting at night, the ULDB is able to maintain a constant volume while the pressure increases and decreases.

The ULDB takes its strength from "tendons," long cords that run from top to bottom like lines of longitude on a globe, dividing the balloon into narrow zones. Within each zone, the plastic film relieves stress by bulging outward. Artists' renderings show only a few such tendons and give a ULDB the appearance of a pumpkin. Actually there are some 300 of them. The internal pressure is low, only around 0.03 pound per square inch, but a ULDB is as large as a football field and has a lot of square inches. "Even with the low pressure it's very tight," says NASA's ULDB project manager, Steve Smith. "The tendons are like guitar strings."

The ULDB program started in 1997, but materials available at the time were either too heavy or lacked the necessary durability. Then in 1999 a new synthetic fiber became available: Zylon.

For decades the ultimate in high-strength materials had been Kevlar, which is used in bulletproof vests. But for large ULDBs, Smith says, "Kevlar is not strong enough. Zylon has about four times the strength. The only thing that's stronger is carbon fiber." A short length of tendon looks like braided brown cord and can hold 3,200 pounds.

Even with this breakthrough, however, ULDBs have had their ups and downs. A June 2000 test flight of a small balloon went well. It stayed aloft for 30 hours, floating steadily at 93,000 feet, even at night. NASA balloon chief Henry Cathey was impressed by its performance. It even stayed up "when flying over a very cold thunderstorm at night, which tends to bring a balloon down in altitude," Cathey says. But during two tests in 2001 of full-size ULDBs, with inflated volumes of 18.4 million cubic feet, the envelopes sprang leaks.

NASA officials plan to continue ULDB flight tests in 2002. Although the balloons aren't ready to carry payloads, scientists are already lining up for places on the launch manifest. Cosmic ray detectors have a high priority on the flight list, and a larger version of Boomerang may also fly on a ULDB.

"People are just waiting for verification that the ULDB will perform and will get those hundred-day flights," says Steve Smith. But even when the ULDB has proved that capability, Smith concedes another problem may interfere with the hundred-day span—a problem springing not from technology but from politics. ULDBs are to fly from Australia and to circle the world repeatedly, but winds will blow them slowly northward—toward countries that do not permit overflights. Diplomats must address these issues, if ULDBs are to remain aloft.

Will these long-duration balloons replace satellites? Astronomer Jonathan Grindlay says that "a 30-hour flight" using a conventional balloon "is not competitive" with a spacecraft. However, "a hundred-day flight is very competitive." Indeed, plans already are afoot to use a ULDB itself as a satellite, in order to fly in the atmosphere of Mars. The idea is to deploy the Mars ULDB from a landing craft during the latter's descent. But let's say that on some future mission a need arises to launch a balloon from the Martian surface. There's a balloon facility we know of with an experienced launch team of very seasoned travelers…

Resto

Ian McCloskey has worked on dozens of kinds of aircraft, but when he first saw the Bat, he wasn't sure how to proceed. It clearly needed repairs, but he had never seen anything like the old glider. "There was a lot of standing back and head-scratching," says McCloskey, manager of the aviation maintenance program at Frederick Community College in Frederick, Maryland.

The Bat was worth restoring, though, as it is one of very few examples surviving (another is at the National Air and Space Museum). Officially designated the ASM-N-2, the Bat dates back to World War II. It was designed to be carried aloft by PB4Y-2 Privateer patrol bombers and other naval aircraft and released at 15,000 to 25,000 feet. Once launched, it would bear its cargo—a 1,000-pound "general purpose" bomb—toward an unlucky target.

The Bat was the United States' first fully automatic guided missile used operationally. Though it was not rocket-propelled, it is considered a guided missile because it used a radar guidance system. The Bat had an early S-band radar homing device, which was linked to the craft's autopilot servo motors. These in turn were linked to elevons, control surfaces on the wings that functioned as both ailerons and elevators, steering the missile to its target. (The radar system called to mind the way bats use sonar for navigating, hence the missile's nickname.)

The Bat was developed through a collaboration between the Navy's Bureau of Ordnance, the Massachusetts Institute of Technology, Bell Labs, and the National Bureau of Standards, with the bureau overseeing the entire program.

Bats first saw service in the spring of 1945 over the Pacific island of Borneo, where they took out several Japanese ships in the Balikpapan harbor. They later destroyed bridges in Burma and other areas.

The missiles were retired in 1953. In the 1960s, the Navy transferred a Bat to the National Bureau of Standards. The bureau (later renamed the National Institute of Standards and Technology) stored it in a warehouse on its campus in Gaithersburg, Maryland.

In subsequent years, several NIST employees, chief among them Reeves Tilley, argued that the Bat should be brought out and displayed, along with other artifacts, to document the bureau's contributions during World War II. NIST historian Lisa Greenhouse and information services director Mary-Deirdre Coraggio decided to go to the warehouse to check on the Bat. Unfortunately, the missile was in pieces, and the pieces needed restoration.

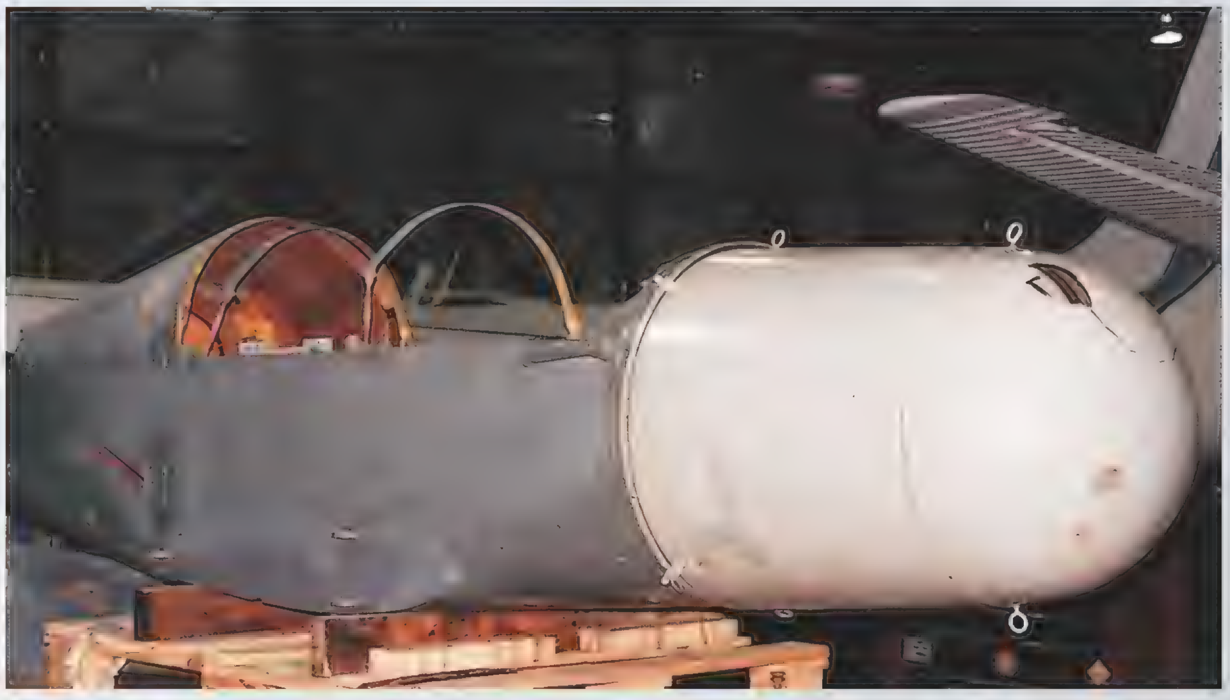
In the Pacific theater of World War II, naval bombers like the Privateer (above) and the Helldiver (below) carried the little airplane-like Bat aloft, then released it to find its way, via radar, to its target.

NIST/U.S. DEPT. OF COMMERCE (2)

ration

The Bat | ASM-N-2 Guided Missile

Clockwise, from left: the fuselage, pre-restoration; Jason Garver painting a vertical fin (both triangular and circular designs were used); a trial assembly showing the extent of restoration necessary; the fuselage, masked for painting.



MICHAEL V. CORAGGIO (4)

As it happened, Coraggio's husband, aerospace engineer Mike Coraggio, had recently graduated from the aircraft maintenance program Ian McCloskey runs in Frederick. He contacted McCloskey to see if he'd like to work on the Bat with his students. McCloskey agreed.

McCloskey, Coraggio, and students Jason Garver and Tom Judkins did most of the work, with help from staffers at Frederick Community College. The restorers started by disassembling, cleaning, and sanding the whole vehicle. Later, they used fiberglass to patch holes in the Bat's plywood skin. The restoration was limited to the Bat's exterior, as the missile had been shipped to the National Bureau of Standards without its internal components. To keep it balanced for display, the team filled its nose with metal plates.

As they worked, the restorers became increasingly impressed with the Bat's construction. "To put that kind of quality workmanship into something you know is going to get destroyed speaks to the work ethic and mentality of the time," Mike Coraggio says.

The Bat was installed in the NIST museum last March. These days, visitors should find new relevance in the old missile, as it is the forebear of the Joint Standoff Weapon, a GPS-guided "smart bomb" that the United States has been using in Afghanistan.

The museum display includes an early 1950s Navy film showing what is probably a training exercise in which one of the missiles is launched at a barge. At 12 feet in length and 10 feet from wingtip to wingtip, it looks like a toy, especially compared to the nearby mothership. But as it swoops down, it brings to mind a hawk diving on prey, an impression of lethality reinforced when the Bat explodes on the barge.

—*Jim Sweeney*

PHOTOGRAPHS BY ERIC LONG AND MARK AVINO

THE FRONT OFFICE

EVERY PILOT NEEDS A PLACE TO WORK.

The voluptuous curves of the Senior Albatross sailplane are the work of William Hawley Bowlus, who got his start in aviation when he hired on at the Ryan Airlines plant in San Diego, California, in 1916 and helped design and build the Ryan NYP *Spirit of St. Louis*. Later, he taught both Charles and Anne Morrow Lindbergh to fly sailplanes and designed a series of craft inspired by high-performance sailplanes that were then being produced in Germany.

He crossed paths with Richard C. duPont, a young glider enthusiast who soon joined him in setting up a small sailplane manufacturing facility in San Fernando, California. When duPont began to set records with the Bowlus sailplane, one onlooker, Warren E. Eaton, became determined to buy one and commissioned Bowlus to build it with a unique mahogany plywood skin. Eaton named it *Falcon* and set records of his own with it.

Embraced in its cabinet-like panel are basic flight instruments (from the top): airspeed indicator, vertical speed indicator; (bottom, left to right) turn-and-bank indicator, altimeter, and magnetic compass.

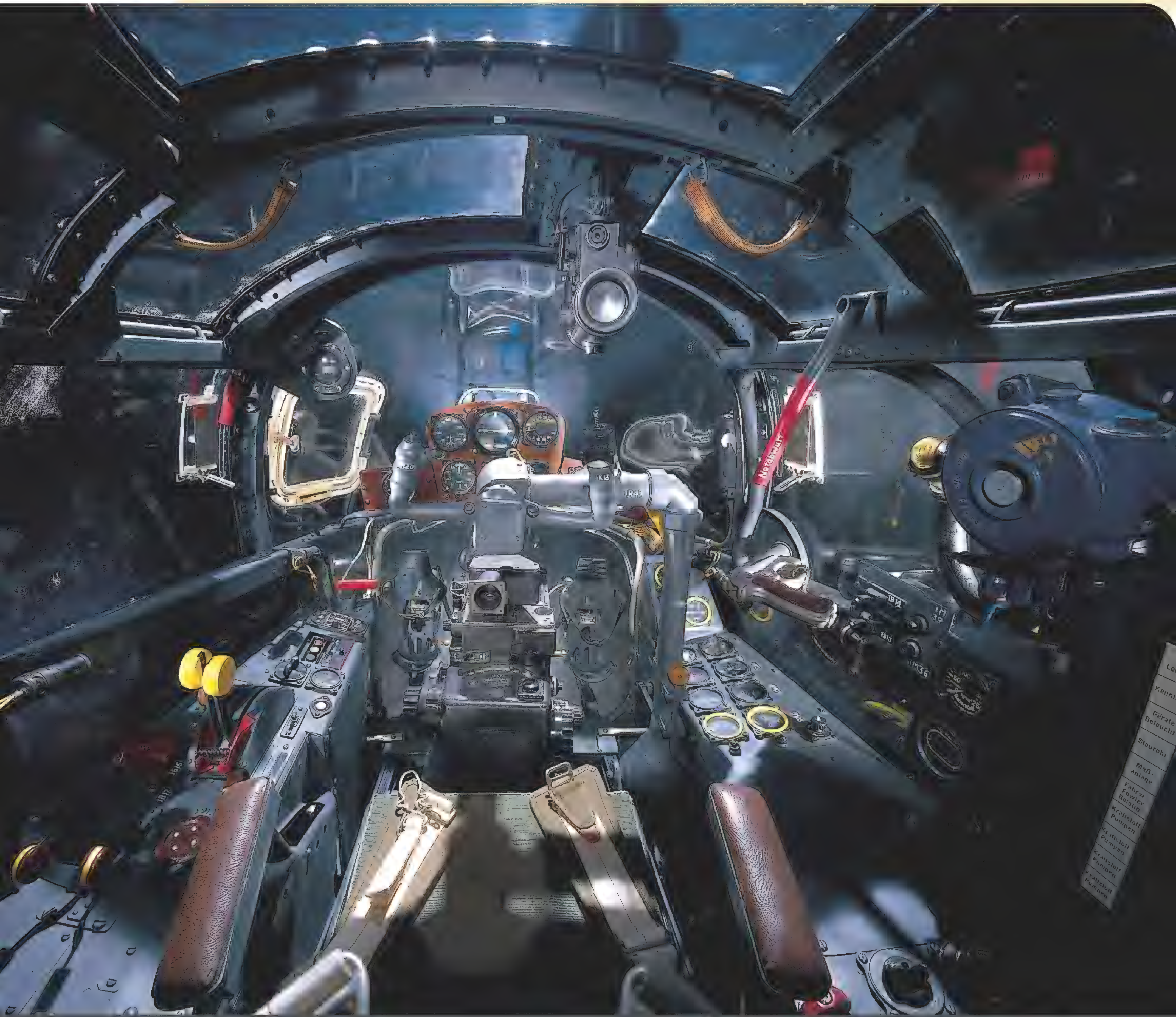
This photograph and the ones that follow appear in a new National Air and Space Museum book, *At the Controls* (Boston Mills Press), which features 70 photographs by Eric Long and Mark Avino, including details of the cockpits of many aircraft in the Museum's collection.

—*The editors*

BOWLUS ALBATROSS

Startling in both appearance and performance, this Luftwaffe Arado Blitz, the world's first bomber to be powered by turbojets, entered combat service flying a photo-recon mission over the Normandy beaches in August 1944, well after the invasion of Europe was under way.

Here in the tight but amply glazed business end, neatly laid out systems include a folding control column that swung out of the way so that the pilot, the lone crewman, could take on the additional role of bombardier, aided by a Lotfe 7K bombsight in the floor. An overhead periscope provided a bombing sight for shallow attack dives and doubled as a gunsight for cannon that fired to the rear in the event any pursuer ever got close enough. Primary flight instruments (in the ocher cluster above the control stick) are grouped in a T-shaped arrangement, much the way they are in today's light airplanes.



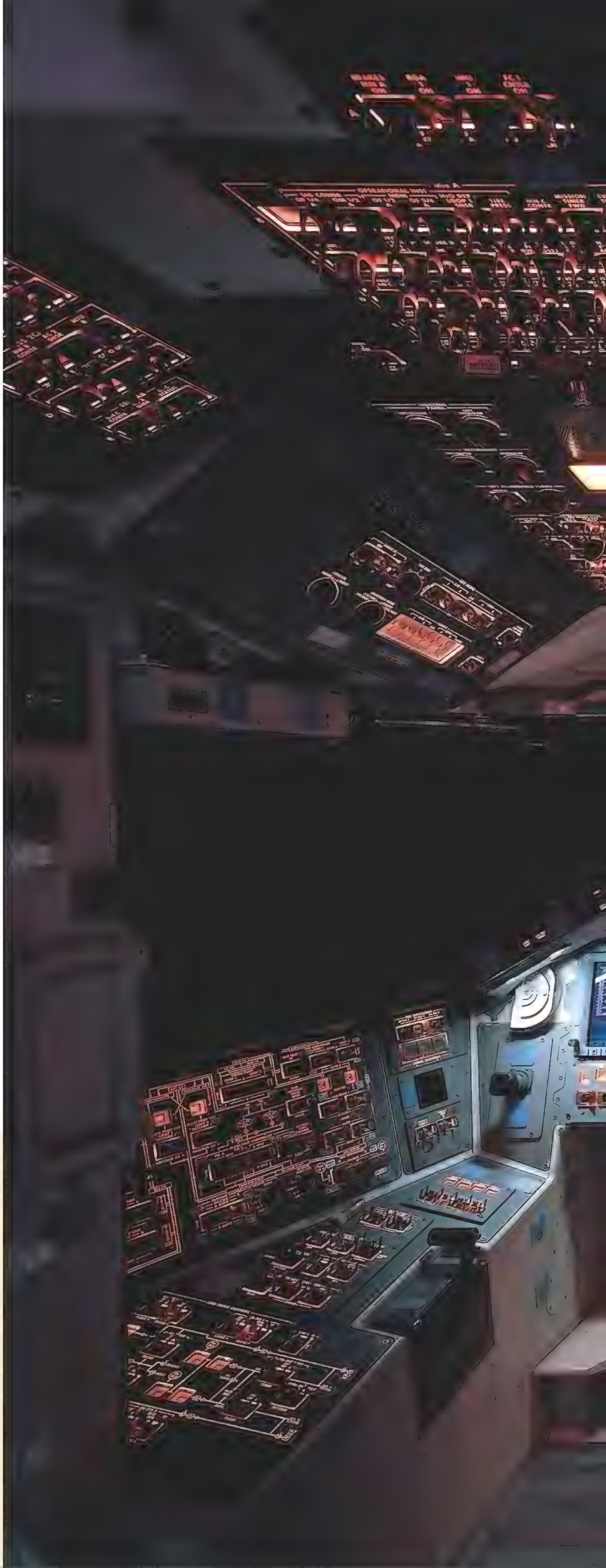
ARADO AR 234B-2 BLITZ

The bright yellow enamel on the control column of the Northrop N-1M, the first flying-wing aircraft built and flown in the United States, extends the canary-like motif of the little experimental airplane's exterior paint scheme.

The N-1M was the first pure expression of John Northrop's obsession: to create the ideal airplane—the "flying wing"—by doing away with its fuselage and tail. As the first of its kind, the N-1M was designed to investigate the aerodynamic qualities of flying wings, so the configuration of its wing could be changed; wing sweep, dihedral (the angle the wing is canted upward from the horizontal), and control surfaces could be adjusted on the ground.

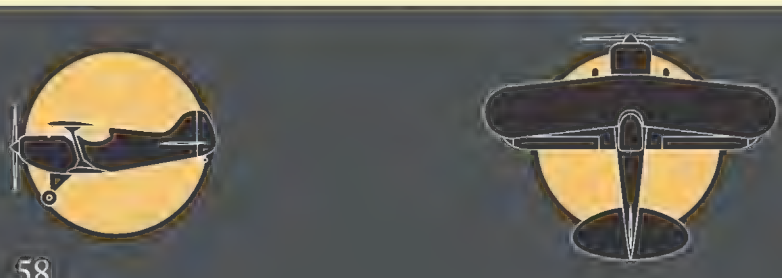
Compared to the unorthodox airframe, the cockpit is fairly conventional, if austere. The control wheel looks suspiciously automotive in origin.

NORTHROP N-1M

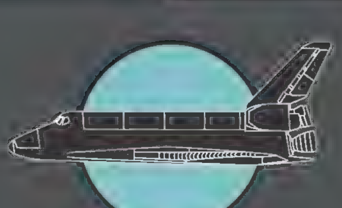


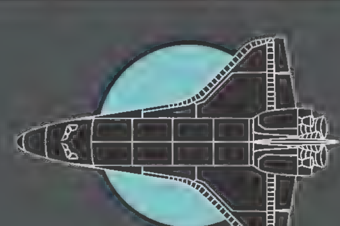
Aerobatic pilot Betty Skelton named her Pitts Special (above), a compact biplane designed by Curtis Pitts in 1945, *Little Stinker*. She also added some personal touches: an upside down bubble indicator for turn coordination during inverted flight (in the middle, just below the compass) and a red button marked SPIN CRASH BURN, about which she wrote: "Actually, it was an engine feather button taken from a [B-17] bomber. It did absolutely nothing, but never failed to bring a quizzical look to the faces of people peeking into my cockpit at air shows." A G-meter measured the loads on the airplane during strenuous maneuvers (it's the round dial with red markers on its rim).

The flight deck of the space shuttle *Columbia* (right) is bathed in a cool electronic glow where the old electro-mechanical flight instruments in the panel have been replaced with flat-panel video displays similar to those used for personal computer monitors. Flight crew members can configure the ultra-reliable displays to present the information they need, and even if one display should fail, the others can pick up the load.



PITTS SPECIAL S-1C





SPACE SHUTTLE *COLUMBIA*

The Roc

Counterclockwise: Technicians aboard the Rose Knot *monitored mission data as the ship's acquisition aid antenna tracked the spacecraft. NASA transformed an old World War II tanker into the* Vanguard, *a state-of-the art spacecraft tracking platform.*

The Vanguard*—as well as the* Redstone *and the* Mercury*—was, beneath the nice paint job, something of a Frankenstein: NASA split the original tanker into pieces, keeping only the bow and stern, rather than spend the time and money to build a new ship.*

ketShips

TRACKING LAUNCHES FROM CAPE CANAVERAL REQUIRED OLD BOATS AND IRON GUTS.

BY DAN KOVALCHIK

Visitors to Florida's Space Coast who want to immerse themselves in the area's remarkable history needn't book tours of NASA's Kennedy Space Center. They can just follow the trail of restaurants, shops, and nightclubs in nearby Cape Canaveral and Cocoa Beach, where 50 years' worth of space memorabilia is hanging on the walls.

True, this tour might suggest that the story of spaceflight is little more than jaunty astronaut smiles and triumphant trails of rocket fire. Persistent visitors, however, will make it to the beach bars, where a generation of locals have hung reminders of the ghost fleet of the Eastern Test Range.

These mementos—life rings, framed pictures of ships, plaques with the boats' insignias—represent the years of the "missile range instrumentation" ships, vessels that cruised to strategic locations around the world to track missiles and spacecraft and record crucial events. Their mission was so vital to the development of space technology that the government spent hundreds of millions of dollars on them. The Navy even put them in a class by themselves, referring to them as T-AGM ships. Twenty-three vessels eventually shared this somewhat cryptic classification, and those who sailed on them remember them as front-row seats to history.

U.S. AIR FORCE (4)

The ships trace their roots to 1950, back when the fledgling Eastern Test Range, which in nine years would include 11 tracking stations from Grand Bahama to Ascension Island, initially consisted of one brand-new launch pad at Cape Canaveral, a dozen makeshift telemetry antenna sites, and lots of open water. That year, the U.S. Army launched two "Bumpers"—V-2 rockets modified to carry a solid-rocket upper stage (see "The Year the Rockets Came," Apr./May 1999). To augment the Cape's rudimentary telemetry sites, the Navy loaned the services of two ships: the destroyer USS *Sarsfield* and a destroyer escort, the USS *Foss*.

Howard Hoge, now an engineer at NASA's Goddard Space Flight Center in Greenbelt, Maryland, was a sonar striker aboard the *Sarsfield*. He remembers the historic first Bumper launch clearly. "We were stationed just a mile or two offshore," he recalls. "I was off-duty, so I was on deck and actually watched the vehicle take off and streak across the sky. Amazing. We tracked it with our Mk25 Fire Director system, which provided radar and optical tracking."

The *Foss*, on the other hand, had taken a position 225 miles downrange, which proved optimistic. The first Bumper covered only about 48 miles; the second, 150 miles.

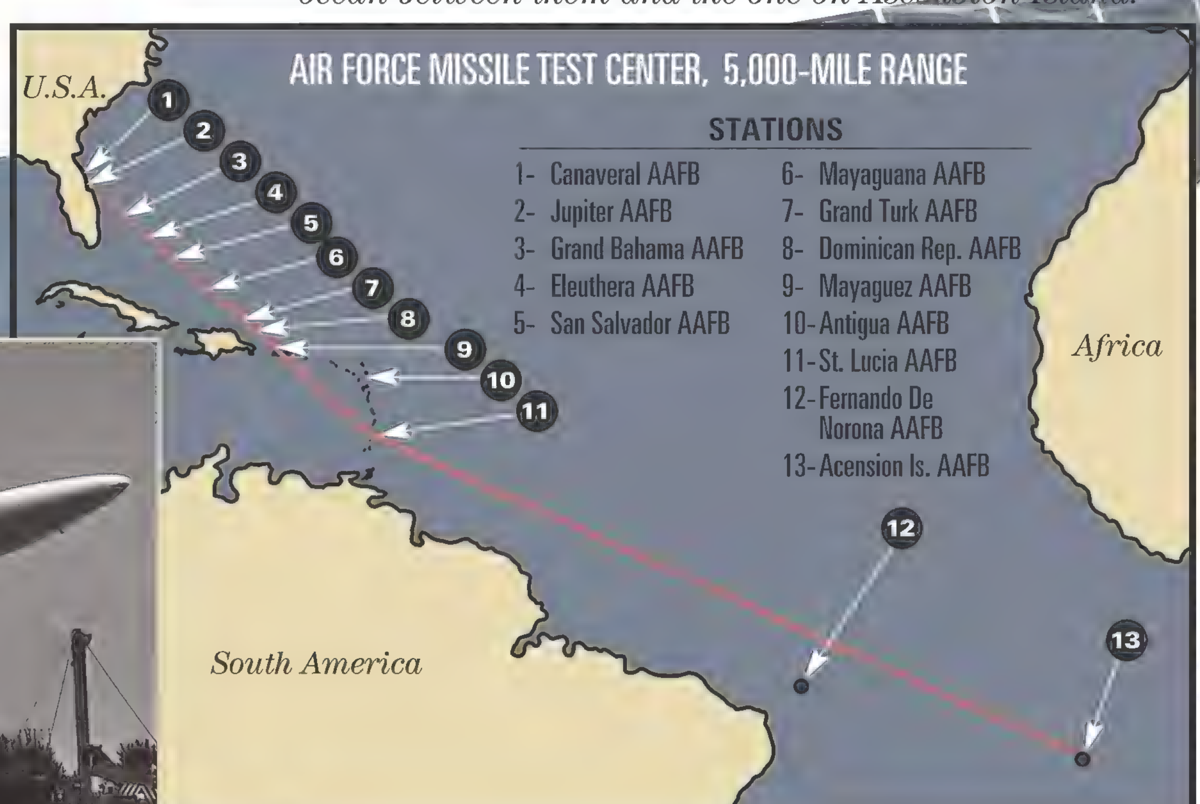
It was an appropriate baptism for the Cape, and yet for the next few years, the growth of the area had nothing to do with rocketry. The Air Force saw rockets as unreliable, inaccurate, and too small to deliver the massive nuclear bombs of the era. Instead, Cape workers focused on subsonic, jet-propelled cruise missiles. One such missile was the Snark, which would become the United States' first intercontinental missile. At the Cape, though, locals remember it more for its numerous failures. So many of these missiles hit the drink off Cape Canaveral that people began referring to that section of the Atlantic as "Snark-infested." But the Snark eventually achieved its intended long-range capability, roughly 5,500 miles, and in so doing, it forced the construction of the tracking stations that would become the Eastern Test Range.

The West Indies stretch 1,600 miles southeast of Cape Canaveral and were perfectly placed for Snark tracking. Beyond these islands, though, range planners had 3,000 miles of unbroken ocean to contend with before tiny Ascension Island came into view. If a Snark went haywire during this leg, the only sign of its demise would be its failure to appear on Ascension's radar screens. In 1956, Air Force officials, in an attempt to plug this gap, went to the mothballed World War II fleet. From it they selected six "FS" class ("Freighter, Small") ships. (James Cagney's much-maligned ship in the movie *Mr. Roberts* was an FS.) The ships were nameless, but the Air Force gave them call signs—*Echo*, *Foxtrot*, *Golf*, *Hotel*, *India*, and *Kilo*—and sent them off for a facelift. For one thing, the port and starboard gun mounts had to go. In their place, shipyard workers installed telemetry antennas. (White radomes covered these antennas, and the resulting assembly came to be known as the ship's bra.) Belowdecks, a cargo hold became the ship's electronics center, with the equipment necessary to lock onto the Snark's beacon and record the data for later mailing back to the Cape.

By October 31, 1957, the ships were in position, ready to track the first Snark to travel the entire length of the range. Michael Birmingham was aboard the *Golf*. Birmingham had been working at the Eleuthera Island tracking site when he heard about the ships. If the prospects of ocean voyages and foreign ports weren't inducement enough, there was always the money. As lead technician, Birmingham's $110 per week would stretch a long way while he was living on the ship. Other perquisites were the 40 percent bonus for working at sea and the one-dollar-per-carton cigarettes, which in 1957 were as important to a technician as his tube-checker. "We had to sign the ship's Articles of Agreement," says Birmingham, "and we laughed when we read that, among other things, the ship's master guaranteed us a daily ration of flour and water. Sailors had probably been signing that same agreement for a hundred years."

After a few weeks at sea, Birmingham got the feeling that

On islands in the West Indies, tracking stations covered a 1,600-mile range, but there was 3,000 miles of open ocean between them and the one on Ascension Island.



The Snark was the United States' first intercontinental missile, and it created the need for the Eastern Test Range.

LEFT PHOTO: U.S. AIR FORCE; MAP: U.S. AIR FORCE/F. MATTHEW HALE

(((Alan Shepard supported Wally Schirra's flight, and for the final Mercury mission, John Glenn took the chair. Glenn's presence proved crucial when Gordon Cooper's electrical systems began to fail. Glenn radioed Cooper with the modified procedures and maneuvers for manual reentry, which resulted in Cooper's flawless return.

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the language in the ship's articles wasn't the only thing that had remained unchanged for a hundred years. "The ocean really pushed our little ship around. We were all young and thought we were tough, but I think even the toughest of us took a turn at the rail," he says. "And the noise! Our quarters were right above the engine. To top it off, we spent 21 days at sea just to record 15 minutes' worth of Snark telemetry. That gave us plenty of time to play cards. Oh, we played a lot of cards."

Turnover was high. After three months, Birmingham decided the incentives weren't enough to warrant another trip on a Freighter, Small. He transferred to range operations in Florida, where he remained a career landlubber.

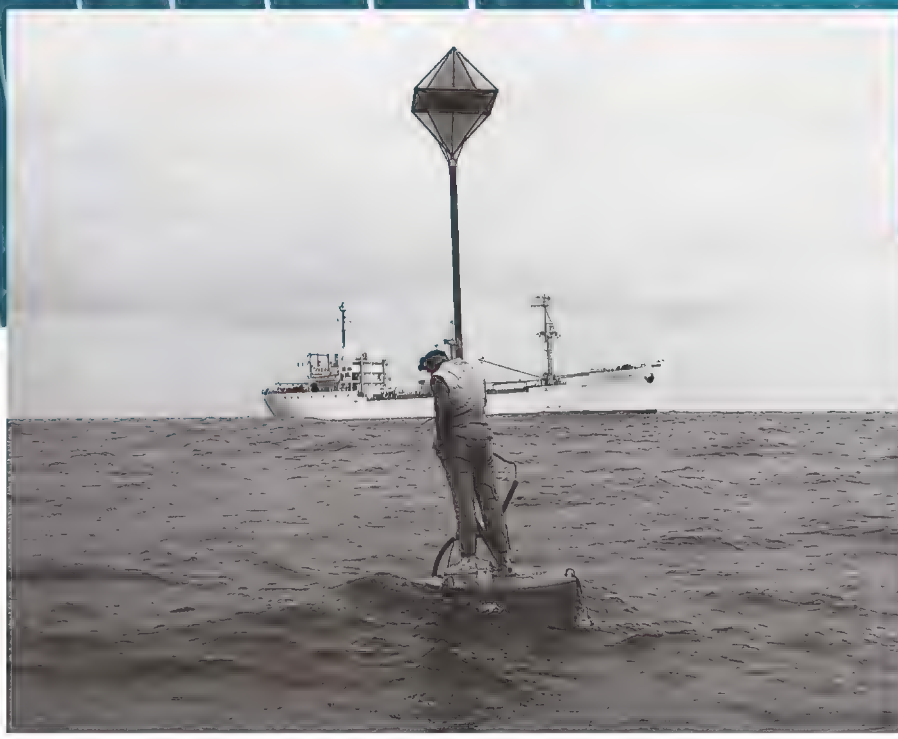
The next batch of range ships appeared just two months after the birth of the FS ships. This curious timing was the result of intelligence indicating that the Soviet Union was dominating ballistic missile research. Suddenly, there was a huge boom in the Cape Canaveral rocket biz, and the Jupiter, Thor, Atlas, and Titan rocket programs brought six more

Eventually, a worldwide array of tracking stations monitored manned missions (below), including Gordon Cooper's notable flight (top).

MAP: U.S. AIR FORCE/F. MATTHEW HALE

Hotel *and the other FS ships sailed from exotic Trinidad and Brazil.*

U.S. AIR FORCE



U.S. AIR FORCE

A lonely job: A Sword Knot *crewman tends to a buoy that helped the ships recover key missile parts.*

ships to the fleet. These were World War II cargo vessels of the C1-M-AV1 class that became the *Sword Knot*, *Rose Knot*, *Timber Hitch*, *Sampan Hitch*, *Coastal Crusader*, and *Coastal Sentry*. The C1-M-AV1s were similar to the FS ships, but at roughly twice the length and 10 times the tonnage, they afforded a much smoother ride.

The smoothness of the ride meant little to technician Jim Hagan, whose first ocean voyage was a trial to test the *Rose Knot*'s new antennas. "I'd never experienced motion sickness before," says Hagan, "but we cast off during rough weather, and soon after, I got that queasy feeling. It didn't go away until I stepped ashore two weeks later."

The lure of the sea must have been strong indeed for Hagan to return to the ship, but return he did. To his relief, *mal de mer* was a no-show. Hagan's seaworthiness proved especially valuable a year later. "We found ourselves in the midst of a hurricane," he says. "I'd never seen seas like that. Each time we fell into a trough, I couldn't see over the next wave, even though I was high above the main deck. Tons of water came over the bow." The crew's quarters were a mess, with drawers flying open and emptying more and more of their contents with each roll. Mealtime was a challenge too. "We wet down the tablecloths to keep the dishes from sliding, but we were constantly grabbing for our plates, glasses, and silverware," Hagan says. "This went on for over 36 hours."

Hagan points out that often, the sea was not the crew's worst enemy. "The food varied from acceptable to awful and got worse the longer we were at sea," he says. "On one trip, the maple syrup began to ferment, giving it a somewhat sour taste. Then the roaches got into it. I was very put off the first time I poured some onto my pancakes, but after a while, I just pushed the roaches aside. Another time, I couldn't chew something in my Hungarian goulash. It was a small Band-Aid."

By 1959, the Cape's missile programs had been pushing the technology envelope for nine years, and digital telemetry systems began to outstrip their analog counterparts. Furthermore, the availability of ocean-bottom contour maps, in concert with the new LORAN system and a top-secret Ships Inertial Navigation System, solved the navigation problem that had limited the tracking radar dishes to land stations. (Ships were already carrying radar for collision prevention and coastal navigation. The improved navigation systems gave the tracking radars the data they needed to pinpoint their targets.)

Suddenly, project leaders found new uses for range instrumentation ships and began clamoring for ships of their own. This led, in rapid succession, to the conversion of another series of World War II vessels: a Liberty ship into the *American Mariner*; a Victory ship into the *Twin Falls Victory*, and two troop transports into the *General Hoyt S. Vandenberg* and the *General H.H. Arnold*.

NASA

And then yet another customer appeared. The year was 1960, and NASA, because of Project Mercury, was building a tracking station network of its own. The Air Force contributed the C1-M-AV1s *Rose Knot* and *Coastal Sentry*, and NASA filled the ships with new instrumentation, including a "command" system, which enabled the ship to transmit commands to the spacecraft, and an "acquisition aid" system, which homed in on the spacecraft's beacon and guided the command and telemetry antennas.

Manned spaceflight had arrived, but despite the advances in technology, NASA still could not guarantee communication between the Cape's mission control center and the remote sites, so communication with the spacecraft was handed off to the network of tracking stations and ships. For each launch every ship hosted a capsule communicator (CapCom) and at least two flight surgeons to monitor spacecraft systems and help astronauts in case they faced health emergencies. (Though the doctors were intended to serve the spacecraft's passengers, one surgeon aboard the *Coastal Sentry* for John Glenn's flight performed an emergency appendectomy on a crewman. The operating room? A converted mess hall.)

At least two astronauts served as CapComs, both aboard the *Coastal Sentry*. Alan Shepard supported Wally Schirra's Mercury 8 flight in October 1962, and for the final Mercury mission, in May 1963, John Glenn took the chair for Gordon Cooper. Glenn's presence proved crucial when Cooper's electrical systems began to fail. Glenn radioed Cooper with the modified procedures and maneuvers for manual reentry, which resulted in Cooper's flawless return.

The ships again showed their value during an emergency that arose in March 1966 during Gemini 8. Dick Bodette, then the *Coastal Sentry*'s operations manager, remembers,

((In the midst of this frantic build-up stepped yet another customer. The year was 1960 and NASA, because of something called Project Mercury, was building a tracking station network of its own. The Air Force contributed the C1-M-AV1s *Rose Knot* and *Coastal Sentry*, and NASA immediately filled the ships with new instrumentation.))))))))

U.S. AIR FORCE

Ham is welcomed home after his flight aboard a Mercury Redstone, which was supported by the Golf *(above). The* Coastal Sentry, *future hero of Gemini 8, sets sail from Port Canaveral (right).*

"There was always a little thrill when we locked onto the astronauts' signal, but this was the 10th mission for some of us, and maybe a bit of the thrill was wearing off. That all changed when we saw the Gemini's wildly fluctuating beacon and realized the oscillations could only be caused by a tumbling spacecraft." Moments later, astronauts Neil Armstrong and Dave Scott confirmed Bodette's fears.

Armstrong stabilized the craft, but Gemini 8's flight plan was suddenly obsolete. The astronauts' lives depended on receiving a new set of deorbit data, and their only chance for receiving it lay with the *Rose Knot* and the *Coastal Sentry*, the only tracking stations in the spacecraft's path. These few minutes of contact proved to be sufficient. Flight controllers invented alternate deorbit plans, and, with the help of a nearby ship that had satellite capability, Bodette's crew received this information and relayed it to the Gemini crew.

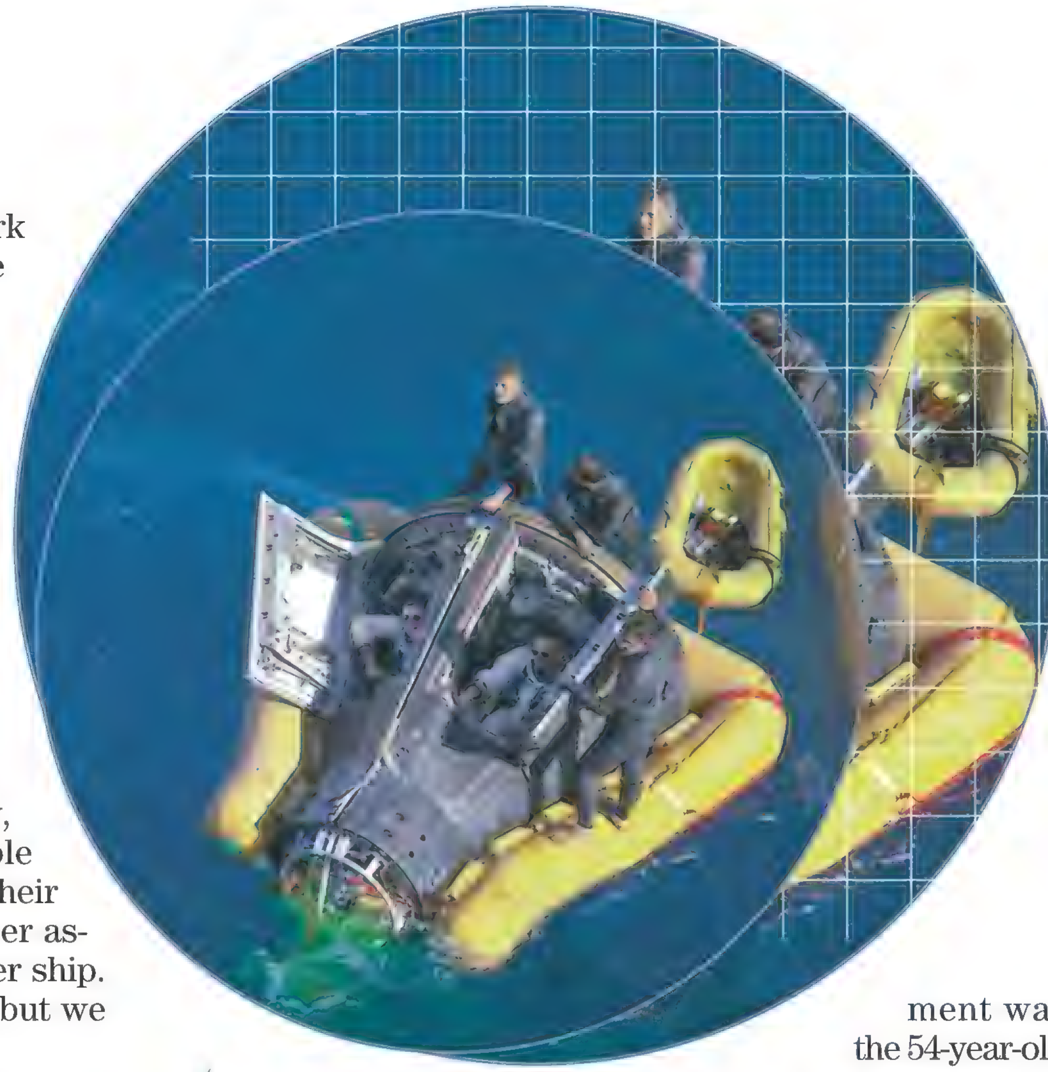
Despite the C1-M-AV1s' stellar performance throughout the Mercury and Gemini programs, the ships weren't equipped to handle the next phase of NASA's plan. Instead, NASA budgeteers allocated $90 million to transform three World War II oil tankers into the *Vanguard*, *Redstone*, and *Mercury*. The new ships were double the length and four times the tonnage of the C1-M-AV1s, creating a vastly improved comfort level for 85 crew members and 108 technicians.

The conversion from forgotten derelicts to shiny transports was accomplished courtesy of the Apollo program, which also initiated a sweeping overhaul of both spacecraft and tracking station electronics. One of the most important changes was the satellite communications link, which would finally guarantee clear, constant contact with the mainland. The Apollo ships' navigational aids marked another area of improvement, allowing navigators to fix their position to within an unheard-of 600 feet. This precision, in turn, enabled flight controllers to more accurately identify the location of the spacecraft. Each ship carried improved versions of the standard technologies, as well as a new satellite navigation system, the forerunner of GPS.

For the first time in manned spaceflight, lunar trajectories became part of the equation. The *Vanguard*, *Redstone*, and *Mercury* would gather this data in the initial phases of the flight, but there was a hole in the reentry support. To fill it, the Western Test Range, which was established in 1958 to extend from Vandenberg Air Force Base in California west to the Indian Ocean, donated two of its Victory ships, *Huntsville* and *Watertown*, for the upgrades.

During Apollo, Mike Linthicum was a young navigation technician on the *Mercury*. Today, he recalls a schedule so tight that one mission's post-flight tasks often collided with the next mission's preflight activities. While the schedule was exhausting, Linthicum did come away with one happy memento of the occasion: His overtime pay allowed him to buy his first Porsche.

But a moonlit night in July 1969 provided a more timeless memento. The *Mercury* was in the China Sea, tracking Apollo 11 in Earth orbit. Linthicum, listening to the network traffic, knew the command for translunar injection was imminent. "I stepped out onto the main deck," he recounts, "and, using the ship's antennas for a guide, I easily spotted the spacecraft just before the controllers transmitted the command. Sure enough, I saw the engine ignite. Then, unbelievably, a halo and then a cross attached themselves to



NASA

the speeding spacecraft. Call it an atmospheric quirk or Act of God, but it was the most exciting thing I've seen in my life. At the very least, I took it as a good omen."

It was not a good omen for the missile-range instrumentation ships. Like so many segments of the space industry, their development peaked during the Apollo project, and their fall came soon after. Evolution demanded that the smaller, suddenly obsolete C1-M-AV1s retire, but surprisingly, just weeks after Apollo 11's historic mission, NASA released the *Redstone*, the *Mercury*, and the *Huntsville* as well, keeping only the *Vanguard* for the remaining six flights.

By 1971, 11 ships had been decommissioned. The availability of improved ground station technology, satellite communications, and increasingly portable telemetry systems doomed the expensive ships. As their numbers dwindled, their crews scrambled for other assignments. Many, like Linthicum, hoped for another ship. "We were traveling and making money, obviously, but we were also making history," he says.

While the range continued to diminish, the Navy needed specialized support for its Polaris, Poseidon, and Trident launches. It added one last ship, the *Range Sentinel*, to the range. Twenty-six years later, in 1997, the *Range Sentinel* relinquished its Port Canaveral berth. It had been the last missile range instrumentation ship on what is now called the Eastern Range. But the title came with an asterisk. Remarkably, the 53-year-old *Range Sentinel*'s replacement was the 54-year-old *Vanguard*, which had been serving several contractors since 1980, when it was stripped of its big antennas and its T-AGM classification. Its new class was the less impressive "Miscellaneous Auxiliary."

The assignment was short-lived. In 1998, after only one year, the last Apollo ship was decommissioned. Today, only the Pacific's *Observation Island* retains the T-AGM classification. Most of the rest have probably been cut up for scrap. There are a few exceptions. The *Coastal Sentry*, hero of Gemini, was destroyed by fire while waiting its turn under the cutter's torch. A private firm bought the *Mercury*, recipient of the $30 million Apollo makeover, and converted it to a cargo ship. When last seen, the ship that sent the command for the Apollo 11 translunar injection burn was hauling Hawaiian sugar to San Francisco. Surely the most ignominious fate belongs to the *Rose Knot*. It last sailed to Point Mugu, California, where the Navy sank it during a training exercise.

Finally, in what may be the least offensive curtain call of all, a group called the Artificial Reefs of the Keys has mounted a "Sink the *Vandenberg*" drive to turn the *General Hoyt S. Vandenberg* into an artificial reef off Key West.

For the ship's old hands, the losses are something to be mourned. There they were, isolated from the world on these 600-foot vibrating, rocking steel islands for weeks at a time. Yet they placed their crews directly in the path of mankind's greatest technological achievement. For those 10 minutes every hour, they *were* the Apollo program.

With the high cost of ship maintenance, though, it doesn't pay to be sentimental. That's why tourists can walk through rocket gardens today and marvel at the evolution of the boosters that pushed humans to the moon. They can view thousands of items representing the Space Race era. But all that remains of the missile range instrumentation ships are the faded pictures on the beach bar walls.

From range instrumentation ship to artificial reef, the Vandenberg's *final fate may be the most honorable of all the range ships (below). Gemini 8 astronauts Neil Armstrong and Dave Scott received a vital uplink from the* Coastal Sentry *that saved their mission—and lives.*

U.S. AIR FORCE

AIR CO

BY ROBERT A. HANSON

In 1957, a young F-100 pilot at Nellis Air Force Base learned a few lessons from the masters.

Power is set at 80 percent. I've been briefed that setting the thrust any higher while holding the brakes is dangerous because the tires could rotate around their rims. I glance at the engine gauges, then look to my right, at my instructor's airplane. He nods; he's ready. I look ahead, down the expanse of the two-mile runway at Nevada's Nellis Air Force Base, release the brakes, and advance the throttle to 100 percent. The acceleration presses me back in the seat as my eyes dart down to check the instruments again. I flick the throttle grip outboard to light the afterburner. As my instructors warned me, there is an immediate loss of thrust, and I go forward against the harness. But suddenly, there is a tremendous bang behind me and I'm nailed back in the seat as the afterburner kicks in. Airspeed increases rapidly: 120 knots, 140, 160, 180. Pull back on the stick, rotate the nose up about 15 degrees as the fighter becomes airborne. Gear up. The runway falls away behind me, and I steepen the climb to reduce airspeed. I pull the throttle grip inboard to bring the engine out of afterburner at 300 knots and get on the climb schedule—a strictly prescribed flightpath with specific altitude and airspeed callouts—that I was taught only a day before. My instructor's aircraft is behind me and I ease the throttle back and start a shallow right turn so he can join up.

I'm flying the North American F-100A Super Sabre for the first time. It's September 20, 1957.

My classmates and I, at Nellis to master the first of the now-legendary Century Series fighters, were at the bottom of a steep learning curve. The aircraft we had been flying—T-33s, F-84s, even F-86s—were either designed or conceived during World War II. The F-100, on the

LEFT: NASM, INSET: COURTESY ROBERT A. HANSON

The F-100A (left) entered Air Force service in 1954. The author (right) was a rookie when he flew this D model.

MBAT U

other hand, represented a new generation of fighter aircraft, the first to make use of the knowledge gained by the Bell X-1 and Douglas D-558 supersonic research programs. The Super Sabre was the first operational fighter capable of reaching Mach 1 in level flight. Speed that a few years earlier had been the sole province of stars like Chuck Yeager and Scott Crossfield was now being made available to us rank-and-file fighter pilots.

Our education in the F-100 would be revolutionary in another sense. Our training class arrived at Nellis just three years after the Air Force had transformed its Fighter Gunnery School there into the Fighter Weapons School, built around a core of visionary Korean War aces who believed combat maneuvers could be quantified in terms of energy transfer and therefore standardized. The Fighter Weapons School instructors were the best fighter pilots in the Air Force, and they frequently came down to the training squadrons to fly with us trainees, sometimes using the training flights as practical experiments in the emerging science of aerial combat. We could hardly know at the time—many of us reported to Nellis on our way to our first fighter wing assignments—that we had stumbled into an opportunity in our careers that would never be repeated. Our short time there—six weeks and a mere 30 training flights—had a profound influence on us and ultimately paid dividends when we flew combat missions in Southeast Asia a decade later.

The 3595th Combat Crew Training Group at Nellis was made up of the Fighter Weapons School, which was organized as its own squadron, and five training squadrons, which introduced pilots to the F-100. Group Commander Bruce Hinton had led an F-86 squadron in Korea and was the first F-86 pilot to shoot down a MiG in that conflict. Before the war ended, he had bagged two more MiGs and damaged seven. Hinton was always ready with a word of encouragement for us students—an unusual trait in a group commander.

We were given three flights to learn how to handle the F-100—we shortened it to "the Hun"—before our training in combat operations began. Those introductory flights were brief—less than an hour—and were intended simply to give us a feel for the airplane. Its wings were only a foot longer than those of the F-86F I had been flying, but the fuselage, which housed a Pratt & Whitney J-57 engine, was nearly seven feet longer. In full afterburner, the J-57's power—16,000 pounds of thrust—was more than three times that of the General Electric J-47 in the F-86, even though the Hun was only 3,000 pounds heavier. It was pure fighter. It could climb to 40,000 feet in four minutes. But it was also vicious.

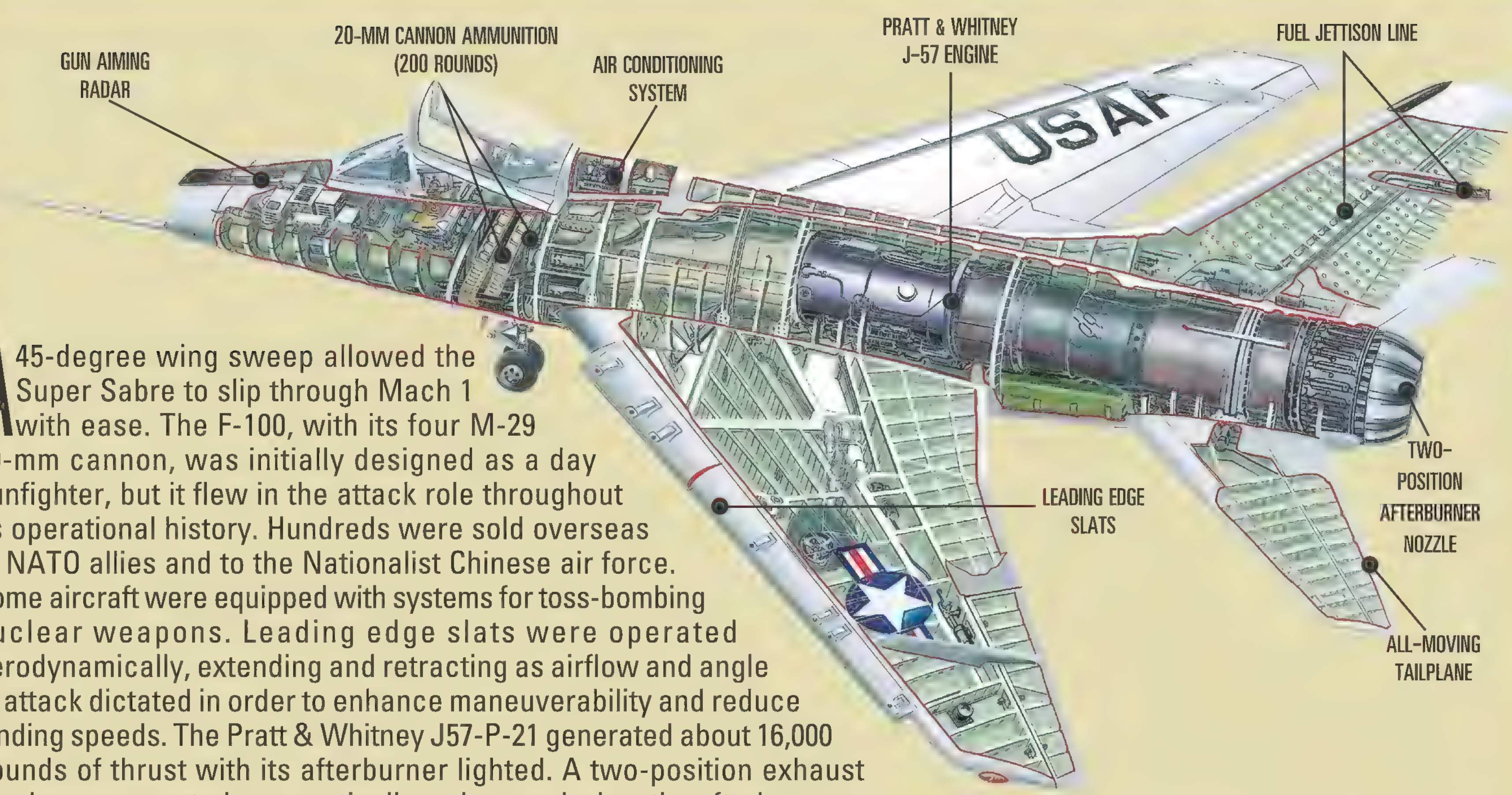
Chuck Wood, one of the young lieutenants who started his training several classes ahead of mine, had a close call in the Hun and ended up finishing his training in my class. We all remember our first takeoff in the F-100, but Wood's introduction may have been a little wilder than most. "I flew the F-84 at Luke [Air Force Base]," he recalls, "and it accelerated so slow on takeoff you could deal a deck of cards while waiting for something to happen. Well, that first takeoff in the Hun, I was just hanging on. My instructor called and said, 'Raise the gear, shut off the [afterburner], and wait for me.' Man, I was out of control."

On Wood's second check-out flight, unfortunately, he found out what "out of control" really meant. Wood was

We were given three flights to learn how to handle the F-100. It was pure fighter. It could climb to 40,000 feet in four minutes. It was also vicious.

NASM

The Super Sabre was the first Air Force fighter to exceed Mach 1 in level flight. Here, newly minted F-100As wait on the ramp at North American's Los Angeles plant.



A 45-degree wing sweep allowed the Super Sabre to slip through Mach 1 with ease. The F-100, with its four M-29 20-mm cannon, was initially designed as a day gunfighter, but it flew in the attack role throughout its operational history. Hundreds were sold overseas to NATO allies and to the Nationalist Chinese air force. Some aircraft were equipped with systems for toss-bombing nuclear weapons. Leading edge slats were operated aerodynamically, extending and retracting as airflow and angle of attack dictated in order to enhance maneuverability and reduce landing speeds. The Pratt & Whitney J57-P-21 generated about 16,000 pounds of thrust with its afterburner lighted. A two-position exhaust nozzle was operated pneumatically and opened when the afterburner was operating. The Hun got its first exposure to combat in Vietnam and had a long service life, finally retiring from the Air Force in 1979.

NORTH AMERICAN F-100A

JOHN BATCHELOR

COURTESY MARY E. HOLTON

John Boyd boards an F-86 in Korea.

climbing from takeoff through 18,000 feet when his instructor pilot advised him that he was losing fuel. "Here I was just getting some small level of confidence after that first wild take-off, and he goes and says that," Wood recounts. He turned back toward Nellis, but halfway through the turn, the fuel gauge hit zero.

"It got quiet," Wood says. He set the glide speed at 220 knots so the RAT, or ram air turbine, would get enough air blowing through its ducts to supply hydraulic and electric power after the engine quit. "I was coming down like a rock, and on short final somebody said, 'Pull up and bail out.' [Another voice] said, 'No, don't. You'll never make it.' Later, when I listened to the tapes, [I heard myself saying] 'Will somebody make up their damn…'

"I hit really hard, and the airplane broke in half just behind the cockpit. I jumped over the side and ran until my oxygen mask, which was still attached in the airplane, spun me around. I disconnected that and then realized I hurt pretty bad, so I lay down. A few minutes later, a medic from the chopper bent over, looked at me, straightened up, and yelled in an incredulous voice, 'Hey! He's still alive.' "

Wood was back flying after two months in traction and six weeks of rehab.

Once we survived our three check-out flights in the Hun, we moved on to the basics of the fighter pilot's craft: air-to-ground gunnery, air-to-air gunnery, and air combat maneuvering, or ACM, a term recently coined for what all of us knew simply as dogfighting. For our air-to-ground training, we dove at a shallow angle and strafed a 20-foot-square cloth target with a huge bull's-eye on a desert range. Air-to-air gunnery training was a little more challenging. We'd go up in a flight of four—one instructor and three trainees—to shoot at what we called "the rag": a six- by 30-foot rectangle of nylon mesh, marked with a bull's-eye and towed on a 1,200-foot cable by a T-33. The idea was to sit on a perch at about 1,500 feet—almost even with the target and about 3,000 feet away from it. We'd then make a graceful, descending, reversing turn into the banner, closing at an angle of about 30 degrees until

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Bruce Hinton had three MiGs to his credit.

we were within 800 to 1,000 feet of the target. Then we'd fire a short burst from the Hun's four 20-mm cannon, relax our pressure on the stick to release the Gs, roll up and over the banner toward wings level, and climb back to the last position in line, always alert for the other three aircraft in the pattern, since the drill was continuous.

The bullets for each airplane were dipped in paint of a distinctive color so they would mark the banner as they went through the mesh, thus identifying the shooter. After the tow plane dropped the rag back at Nellis, we retrieved it to assess our lethality. The drill required some serious precision flying (and was really great fun), but not many of us students got more than a few hits.

To show us how it could be done, Captain Cal Davey came down from the school to fly air-to-air with us. Davey was one of the best guns in the Air Force, according to Hinton. He had been a member of the winning Nellis team at the 1955 U.S. Air Force Worldwide Gunnery Meet, a competition among all the Air Force fighter groups. The Hun had a small radar, part of a lead computing sight that helped the pilot aim its four 20-mm rapid-fire M-29 guns, but Davey didn't need it; he could see the bullets on their way to the target and adjust his aim point. He would brag that he could put a grease pencil mark on his windscreen and hit the target 98 percent of the time. And he could. He briefed us on speed control, G control, closing, aiming, tracking, countering yaw, breathing—all the finer points a pilot has to keep in mind while pursuing a target.

During these briefings, Davey, who thought about and flew tactics in three dimensions while the rest of us were still operating in two, would get very excited about the theories of aerial gunnery he was explaining. He would wave his arms and talk a mile a minute. "He worried that nobody would understand him," Hinton says, "and of course nobody did."

In 1958 Davey was on another winning gunnery team, this one a competition within the Tactical Air Command. Hinton, who led the team that year, remembers Davey's method during the competitions: "Cal would always fly number four so that on his next to last pass, he could check to see if there were good hits from all the team members. If it didn't look good, he would shoot the banner off the tow cable so it would be lost over the desert and the mission declared invalid. Then we would get to fly it again."

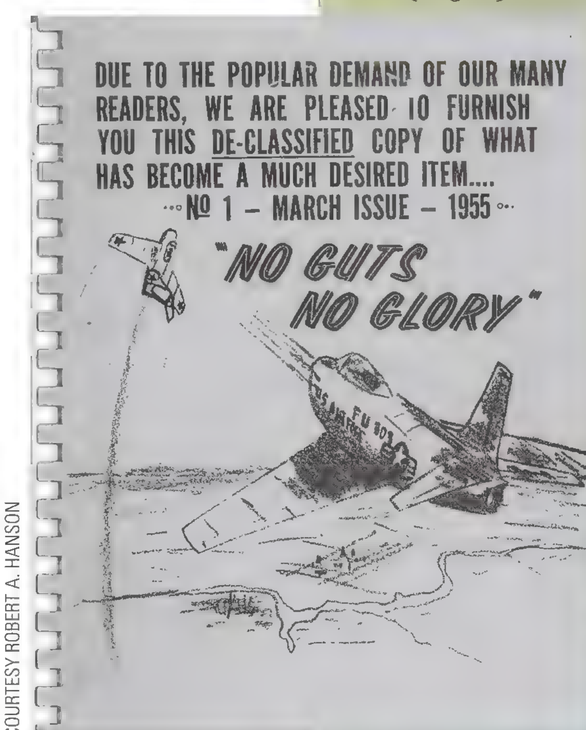
Sadly, the great Cal Davey was killed in Germany while flying an instrument approach in bad weather in an F-100F. That accident has always seemed to me one of the cruel ironies of this business.

Air combat maneuvering was the most strenuous—and dangerous—subject in the syllabus, and our textbook was written by one of the most celebrated fighter pilots of the day, Major Frederick "Boots" Blesse, who achieved double-ace status in the Korean War. Following his success in Korea, Blesse became a training squadron commander at Nellis and wrote a tactics manual, *No Guts, No Glory*, that soon became the bible of aerial combat throughout the Air Force. (Almost 20 years later, it was still being distributed to tactical units in the field.) Each of us carried a copy, memorizing the rules, visualizing the maneuvers, and planning our future kills.

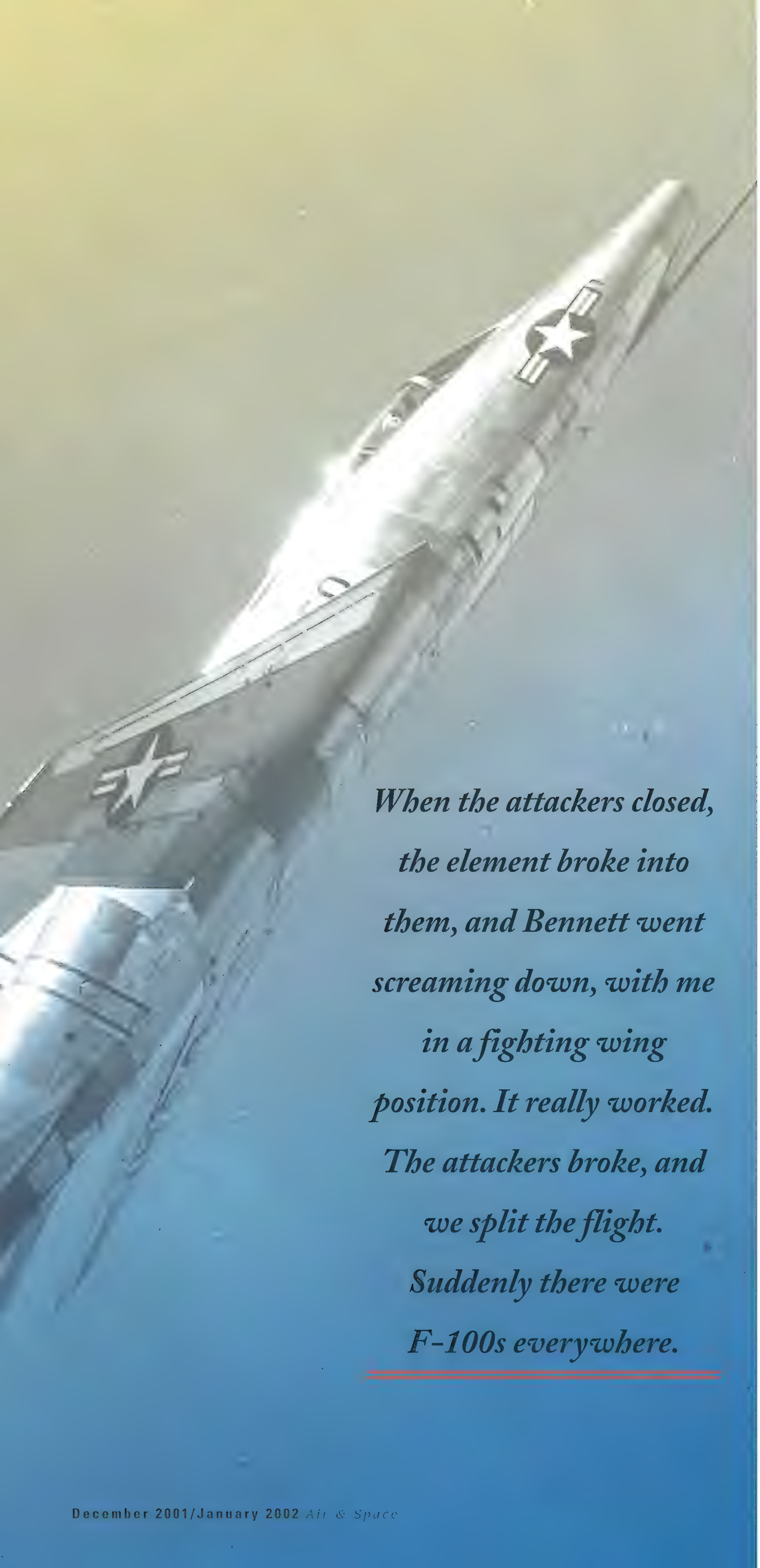
We had many occasions during our training flights to practice the principles in Blesse's manual—and even develop variations on them. "Find the con level," Blesse advises early in the manual. "When possible, cruise with your high element just below the con

USAF

Frederick "Boots" Blesse (above) wrote a booklet (below) that became doctrine, but the Hun's quirks had to be lived to be learned (right).



COURTESY ROBERT A. HANSON



When the attackers closed, the element broke into them, and Bennett went screaming down, with me in a fighting wing position. It really worked. The attackers broke, and we split the flight. Suddenly there were F-100s everywhere.

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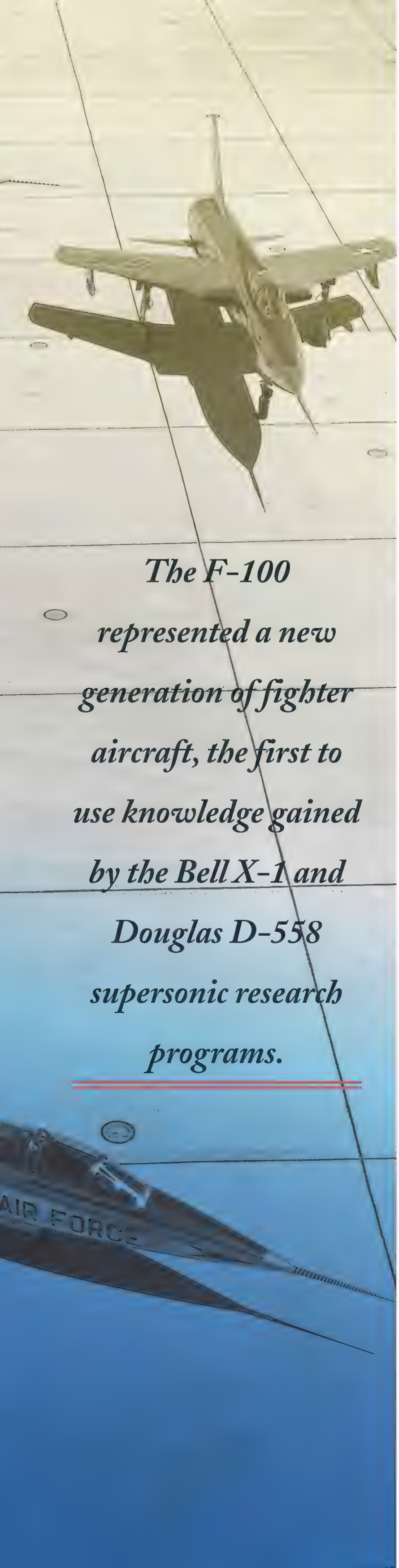
level and you'll quickly see any attack made on your flight from above." The "con level" is the altitude at which the air is cold enough to make the engine's hot exhaust condense and form smoke-like contrails—condensation trails. Instructor John Bennett and I one day used that bit of advice as the nucleus for a devious plan.

I was number two, on Bennett's wing, in a flight of four. We were heading out to the Air Combat Maneuvering area, looking for a fight from some of our classmates. Bennett and I decided to leave the element in the con level; he and I would climb above the cons, so when the element, easily seen by their contrails, was attacked, we would be able to swoop in before the attackers knew of our presence. We made it to 48,000 feet with the element conning heavily around 35,000 feet before we saw the cons of a flight headed for our bait. When the attackers closed, the element broke into them and Bennett went screaming down, with me in a fighting wing position. It really worked. The attackers broke and we split the flight, but suddenly there were F-100s everywhere. Another four-ship had joined in. John was closing fast on a flight of two, in a left descending turn. They were pulling hard, up into us, streamers off the wingtips, when suddenly the wingman did a quick roll over the top and off to the right. Inertial coupling had struck. In the F-100, this was the result of high-G maneuvering—a hard turn, usually to the left. The Pratt & Whitney J-57 engine produced such torque—16 stages of turbines revolving 38,000 times a minute—that the airplane wanted to roll around the engine. Add that to the centrifugal force resulting from the bank, which caused the nose and tail to swing out perpendicular to the rotation axis, and the aircraft departs. The F-100 also had a tendency toward adverse yaw, an aerodynamic coupling of the roll and yaw axes of an aircraft so that a pure roll input could produce a hard yaw: A left roll input, for example, could cause the nose to slice right. When the two coupling phenomena ganged up, the pilot was only along for the ride. By releasing the back pressure, you could fly out of the condition, but the fight would then be well behind you.

When I saw that wingman, straining to hold on to defend his lead's tail, tumble over the top, I laughed out loud, imagining the expression on the pilot's face. We would all experience it during our training.

These were the kinds of misadventures we would analyze and reanalyze in the debriefing following the flight and re-reanalyze at the officers' club following the day's flying. The nightly discussions of maneuvers, mistakes, and triumphs—and you missed "beer call" only if you were dead or close to it—were sometimes as valuable as, if much louder than, the post-flight analysis. (Sometimes they weren't valuable at all, but there was never any shortage of opinions.) And of course we hung on every word as Hinton, Davey, and the other instructors explained their theories and told their war stories. Blesse, who had been transferred to Combat Crew Training Headquarters at Randolph Air Force Base in San Antonio, spent a lot of time back at Nellis and was a frequent guest of honor at these bull sessions. One of the most colorful of that crowd eventually became the driving force for the development of the F-16 lightweight fighter and played an important role in the development of the F-15 as well. Captain John Boyd, who had degrees in economics and electrical engineering and spent a good deal of his time in the Air Force agitating commanding officers and otherwise bucking the system, was larger than life, boisterous, profane—and an incredible pilot. He had a standing bet—"40 seconds or $40," which meant that within 40 seconds he could turn the tables on a pilot who had "gotten at his six" and collect $40. If it took Boyd longer, he'd pay the pilot.

To my knowledge Boyd never had to pay up. I flew with him once, for one-on-one training in combat maneuvering. He put me at an altitude above him and let me make a clean pursuit curve to his six o'clock. All the while, Boyd was increasing his Gs in a turn, just enough to keep me from pulling lead—getting in a position to aim my guns above and ahead of him. Boyd let me begin edging up, getting the pipper (an electronic light superimposed on the windscreen) on his



The F-100 represented a new generation of fighter aircraft, the first to use knowledge gained by the Bell X-1 and Douglas D-558 supersonic research programs.

canopy. On the radio, he asked repeatedly, "You hacking me, buddy?"—Did I have my sight on his canopy?—and I, pulling Gs to out-turn him, kept grunting "Not yet." When finally I said, "Yes, I'm hacking you," his Hun did the most incredible flip-flops right in front of me and disappeared—only to end up behind me.

His technique was to pull very high Gs and, using the horizontal stabilizer for a speed brake—slow suddenly for no apparent reason. Boyd would yank the stick back—*wham, wham, wham*—repeatedly deflecting the stabilizer, which moved as a single surface, during a high-G turn. His pursuer would overshoot him every time. This was a maneuver you tried only if you knew how to get yourself out of the extreme attitudes that resulted.

Another of Boyd's favorite maneuvers once you had closed on him was to pull up into a vertical climb. Of course you followed. He would shoot straight up until he ran out of airspeed, then do a rudder reverse, an input that caused the airplane to go from nose up to nose down, and you would be looking straight up the intake of his F-100. It was frightening, to say the least. Later, during one of his violent maneuvers, Boyd blew out the hydraulic system's pop-off valves—they relieve the pressure when the system exceeds its maximum design limits—and lost his controls. He had to eject. His commander grounded him for losing an aircraft, but Boyd was able to prove the loss had occurred because of a weakness in the system's design. Reinstated, he continued his explorations.

Lesser pilots weren't as lucky. The F-100A was a brute. It sat back, squatting on its haunches with that gaping intake and looking as though it might take a bite out of you if you got too close. The Hun took a bite out of quite a few. Nearly 25 percent of the total number of F-100s produced were lost in accidents. We were briefed on some of its quirks, which were being ironed out but still needed to be respected.

The supersonic Century Series circle started at 100 and included (from bottom, clockwise) the F-104, the Hun, the F-102, the F-101, and the F-105; the F-106 is not pictured.

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One problem was that modulating the power in afterburner could cause the burner to go out. The solution was to not modulate power on takeoff. We were directed to take whatever we got. If an aircraft happened to have more power than the leader's, that aircraft's pilot would take over as lead. Once safely airborne and out of burner, we would sort out the positions. It made formation flying a little awkward, but we got good at join-ups.

The Hun also introduced us to compressor stalls, which occurred when a pilot, flying at max power and pulling heavy Gs, got the nose too high and the speed too low and starved the engine inlet of air. The combination of too much fuel and too little air caused an explosion in the engine's turbine section. Inside the cockpit, the pilot felt a horrendous *BAM* that struck the floor with enough force to lift his feet off the rudder pedals, and the airplane would slow drastically. An observer would see flames shoot out both intake and exhaust. The pilot could clear the condition by releasing pressure on the stick and getting the nose down—increasing airflow through the engine. Of course if an attacker was behind you at the time, you were dog meat.

Nine F-100As were lost before our class arrived at Nellis, and a few more were lost after we left, but my class was lucky. We lost none.

After training, I arrived at the 31st Tactical Fighter Wing at Turner Air Force Base in Georgia a couple of days before Thanksgiving, ready, or at least willing, to fly the F-100D. The first thing I learned was that three friends of mine, in the training class just ahead of me, had already been killed in F-100 accidents at their assigned units. It was not a forgiving airplane.

The Fighter Weapons School continued to develop, and it turned out the best fighter pilots in the world. In 1968, a cadre from the school went to Naval Air Station Miramar in California and helped the Navy establish its Top Gun School. Today, the school has dropped "Fighter" from its name. The new Weapons School offers instructor courses in many combat aircraft, including the B-1, the B-52, and even the HH-60 helicopter. I imagine it's still a pretty exciting place.

SIGHTINGS

As Russia continues searching for oil, many cultures deep inside western Siberia are being damaged by the quest—wide-ranging drilling diminishes the local hunting and fishing opportunities. But some groups remain untouched, and photographer Scott Warren, who is based in Durango, Colorado, has been documenting two of them, the Khantys and the Nenets, before they too are irrevocably changed.

Inside Siberia, Warren's means of transport is the workhorse of Russian aviation, the Mi-8 helicopter. Operator Tyumen Trans Aviation flies food, fuel, and mail—even livestock—to the villages. They fly kids to schools and reunite families for holidays.

Dusya Moldanov, flying to her village of Numto, waits for her home to scroll into view (left). "The land below is a mosaic of sinuous rivers, lakes, forests, and marshes," Warren says. "She undoubtedly knows it like the back of her hand." In Kazym, villagers load up a helicopter (left, inset), and on the ground in Numto, a girl escapes the blowing sand during a landing (below). Sometimes the helicopters don't even touch down. "At some reindeer camps, they had to hover just off the swampy ground while I jumped out," Warren recalls. "I sunk in to my knees."

The Liberators

Wild Blue: The Men and Boys Who Flew the B-24s Over Germany

by Stephen Ambrose. Simon & Schuster, 2001. 299 pp., $26.00 (hardbound).

NASM SI NEGATIVE 92-4013

When he campaigned for the presidency on an anti-war platform in 1972, Senator George McGovern would not allow his staff to publicize his wartime heroism. During World War II McGovern flew 35 combat missions as pilot of a B-24 Liberator in Italy and received numerous combat awards. The B-24 was built "like a Mack truck," says *Wild Blue* author Stephen Ambrose.

Bomber crews who served with the Fifteenth Air Force in Italy have seldom received the recognition that went to their brothers in the Eighth Air Force in England. Those who flew the B-24 Liberator have long lived in the shadow of the pilots who flew the better-known B-17 Flying Fortress, even though the B-24 was built in greater numbers, flew faster, carried more bombs, and had greater range. *Wild Blue* corrects this injustice. And Ambrose shines brightest when he chronicles the everyday soldiers who won World War II and came, later, to be called the greatest generation. They were young. Many had never before seen an airplane. They launched from airfields that were baked in raw heat part of the year and covered with mud the rest, and they had to fly their missions in frigid cold at altitudes where, Ambrose tells us, "[t]he wind blew through the airplane like fury, especially from the waist gunners' windows and whenever the bomb bay doors were open."

Then there was the flak. McGovern's crew never saw a German fighter, but on one mission, McGovern told the author, "The sky became solid black. Then, in that solid black, you'd see these huge angry flashes of red, which was another shell exploding." That day, McGovern's airplane, the *Dakota Queen*, took 110 hits.

Wild Blue was released almost simultaneously with the critically acclaimed, $135 million HBO television series based on Ambrose's saga of an Army airborne company, "Band of Brothers." Comparing the two makes it evident that America's most visible military historian is more comfortable with soldiers than airmen.

Many books contain minor errors, but the glitches in *Wild Blue* are egregious and astonishing. A sign imploring airmen to "fly and fight" did not appear in the office of General Henry H. "Hap" Arnold during World War II, as Ambrose tells us, but rather in the Pentagon during the Vietnam era. While telling of a B-24 pilot who stuck his head out the side window to see during a rain, Ambrose asserts that the Liberator had no windshield wipers, but most did, including McGovern's. Absurdly, McGovern's trainer, a PT-19 Cornell, is identified as "PT 109," which was the hull number of John F. Kennedy's Navy torpedo boat.

There is more. Ambrose's researcher, his son Hugh Ambrose, attended reunions of B-24 veterans and interviewed many, leaving the impression that the subject of this book would be what its subtitle says: "The Men and Boys Who Flew the B-24s Over Germany." "It's false advertising," says Harry Bremner of Corona del Mar, California, who logged 1,000 hours as a

FOR ALL AGES

Big Book of Airplanes: The Fastest and Most Unusual Planes Ever Made

by Caroline Bingham. DK Publishing, 2001. 32 pp., $14.95 (hardbound).

Great big color photos of various types of aircraft, with key features plainly labeled with easy-to-read text. A great primer for a future stick jockey or airshow junkie.

B-24 instructor pilot. In a telephone interview, Bremner told me, "I thought this book would be about all who flew B-24s in Europe." The book is instead an account of the wartime experience of one pilot, his airplane, and his crew. Some veterans who respect McGovern's wartime service felt differently about his catastrophic 1972 election race against Richard M. Nixon. They might have been less inclined to purchase this volume had it been promoted as what it is.

That would be unfortunate. Although *Wild Blue* does not cover the subject matter its title suggests, it is a compelling account of men at war—and one of the few tributes to a bomber that deserves attention and acclaim.

—Robert F. Dorr is the author of B-24 Liberator Units of the Fifteenth Air Force *(Osprey, 2001).*

Flight: My Life in Mission Control

by Chris Kraft. EP Dutton, 2001. 370 pp., $25.00 (hardbound).

In recent years, frontline stories of the space race have enjoyed a resurgence. Accounts such as astronaut Jim Lovell's Apollo 13 memoir touch a collective nerve. The raw details of astronauts' exploits on the ground and in space, their cool in the face of danger and potential death return us to a unique period, renewing our interest in themes of the heroic, of commitment to goals that transcend the individual.

Chris Kraft's excellent memoir adds a crucial perspective to these frontline stories. Kraft served as flight director—the manager of mission control—for the Mercury and most of the Gemini missions. For the last Gemini missions and the first Apollo missions he oversaw all aspects of flight operations; in the 1970s he became director of the Manned Spacecraft Center (later renamed the Johnson Space Center). Kraft's first role provides the emotional heart of this memoir—and the book's title. In the close, interdependent community of those responsible for exploring space—a new, high-stakes, dangerous activity—Kraft's moniker, "flight," reflected his central role in making life-and-death decisions during the first U.S. missions into space.

As the nation marshalled resources to land a man on the moon, the space effort became a sprawling enterprise, with hundreds of institutions and hundreds of thousands of people. Kraft's memoir highlights mission control's special role: It married national policy and the work of thousands to the planning and conducting of the missions.

As "flight," Kraft played several crucial roles. One is widely known through film depictions—the voice in the ear of astronauts during missions, monitoring the pulse of things, ready to make tough decisions quickly. But his other responsibilities were essential in focusing the national space effort. One was building up mission control itself—a new entity Kraft had to create from scratch, growing from a handful of people after Sputnik to thousands at the height of Apollo, from no specialized facilities to a worldwide communications network. Another task was to plan each mission. Kraft recalls in detail how he and his staff had to master a mountain of information on spacecraft systems, their components, and their potential points of failure. The staff members also had to devise responses to such contingencies—and have all this at the ready during flights.

In the late 1940s and 1950s, Kraft worked as a test engineer at the National Advisory Committee for Aeronautics' Langley Field in Virginia, and the experience strongly influenced his approach to management and problem-solving at mission control.

This early work instilled a straight-forward, honest ethic in Kraft that shines through in his memoir. The book is rich in detail on the growing pains of mission control, on the risks of learning flight operations in the heat of the space race, on the nitty-gritty of each mission, on NASA's bureaucracy, and on Kraft's

relationships with dominant figures of the period—the astronauts, Wernher von Braun, Robert Gilruth (his hero), George Mueller, and others. On the Apollo 1 capsule fire, Kraft is withering in his assessment of prime contractor North American yet acknowledges that the tragedy was key to correcting the moon program's flaws. This honesty, depth of detail, and Kraft's crucial role in the space race make his memoir one of the very best accounts of the first, heady days of exploration.

—Martin Collins is a curator in the Space History Division of the National Air and Space Museum.

Hitler's Personal Pilot: The Life And Times of Hans Baur

by Glenn Sweeting. Brassey's, 2001. 368 pp., $27.95 (hardbound).

This book is a departure for Glenn Sweeting, the former curator of flight equipment at the National Air and Space Museum, whose earlier tomes dealt with the arcana of uniforms, oxygen masks, and survival kits.

Yet the same attention to detail that won Sweeting praise for his earlier books is evident here. *Hitler's Personal Pilot: The Life and Times of Hans Baur* puts not only Adolf Hitler's little-known pilot under a microscope, but Hitler and Nazism as well.

Baur was rare among Hitler's senior aides in the way he attained his job—a position he would hold for 14 years. Instead of Baur engaging in a vicious battle for Hitler's favors, the customary way people got jobs in the Third Reich, Hitler himself sought out and tapped the surprised and flattered airman, who was a decorated World War I pilot and one of the most experienced fliers in all the Reich. As a Lufthansa pilot, Baur helped to build Germany's fledgling airline and civil aviation industry.

Rather than acquiescence, in Baur the German leader found possibly nobler traits. One is Baur's alarming willingness to question, even baldly contradict, his master, who clearly held the pilot in high esteem (the German leader served as Baur's best man and gave the groom a new Mercedes). Tired of Hitler's continual badgering him to become a vegetarian, the pilot finally told off his boss, as few among Hitler's staff would have dared to do.

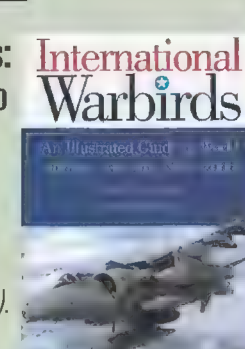
Of Baur's honorific rank of colonel in the SS and complicity in its monumental crimes, Sweeting writes, "It is believed that Hitler's personal security was the real purpose of Baur's entry into the SS…. He could carry a gun and have arrest authority, actively [protecting] Hitler as well as receiving all of the prerogatives and preferential treatment necessary to perform his unique job as personal pilot for the Fuehrer." According to Sweeting, Baur's motivation for joining the SS was in part financial: The affiliation would defray the loss of the pilot's Lufthansa salary.

Sweeting reports that Baur claimed not to believe the mounting evidence of the Nazi regime's butchery. During the 1960s, the pilot told a Sweeting collaborator that the tales of genocide were only Allied propaganda. By drawing from Baur's obscure 1971 memoirs, Sweeting argues that essentially simple souls can be drawn into a miasma where decency can be replaced with groupthink and despotism. Sweeting also lays out all the post-World War I foundations—the Versailles Treaty and the flaws of the Weimar government—that set the stage for Nazism and influenced Baur.

Sweeting concludes that Baur was a paradox, not unlike so many other Germans during the Third Reich. "On the one hand he was a brave, patriotic, hardworking family man, seemingly possessing many admirable character attributes. But...he was also a man willing to devote his entire life and all his energy...in support of a demonic tyrant [who brought] misery and destruction to his own countrymen and to millions of [other] people...."

REFERENCE

International Warbirds: An Illustrated Guide to Military Aircraft, 1914–2000



by John C. Fredriksen. ABC-CLIO, 2001. 387 pp., $75.00 (hardbound).

Aimed at those who want to round out their libraries with an easy-to-use reference on foreign aircraft, this book can be searched by era, manufacturer, or country.

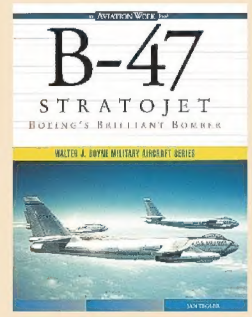
In the end, we don't have an accurate picture of Baur, and Sweeting wonders whether the pilot can ever be known. Loyalty, Sweeting seems to say, is somehow ennobling in its own right, regardless of the purposes it serves. Well, maybe....

There are unique insights here, but Sweeting might have gotten more weight for his analysis had he provided more excerpts from Baur's memoirs. *Hitler's Personal Pilot* paints a surprisingly sympathetic portrait of an essentially guileless fellow who chauffered Hitler from the Days of Struggle to the Nazi Goetterdaemerung in 1945.
—David Walsh is a freelance writer specializing in aviation history.

POSTMODERN BOMBER

B-47 Stratojet: Boeing's Brilliant Bomber

by Jan Tegler. McGraw-Hill, 2000. 169 pp., color and b&w photos, $36.00 (hardbound).



B-47 features a color photo section and numerous reprints from the Stratojet's flight manual. Other aircraft featured in the Military Aircraft Series, edited by *Air & Space/Smithsonian* founder Walter J. Boyne, include the F-22 Raptor, B-1 Lancer, F/A-18 Hornet, B-17 Flying Fortress, and F-105 Thunderchief.

By Any Means Necessary

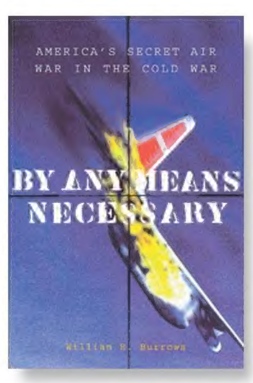
by William Burrows. Farrar Straus & Giroux, 2001. 416 pages, $27.00 (hardbound).

Most readers of this magazine have heard the numerous rumors that during the cold war, some Americans were taken prisoner by Communist-bloc countries and never returned to U.S. shores. In this book, William Burrows, a frequent contributor to *Air & Space/Smithsonian*, provides evidence that he says supports these stories. Examining nearly every incident of cold war aerial sleuthing that led to either the deaths or near loss of air crew, Burrows lays out the gruesome secrets of how and why the missions were flown and how they ended. "Lays out" is the polite way of saying it. This is a disemboweling, with excruciating attention paid to every detail.

The author found surviving airmen who tell harrowing tales of narrow escape, some going public for the first time. He interviewed family members who were deliberately misinformed about the fate of their loved ones. And he leaves the reader feeling that it might all still be going on. Satellites and unmanned vehicles may have taken over some of the most dangerous aerial reconnaissance missions, but the policy of refusing to acknowledge Americans captured in the act of gathering intelligence information cannot be said to have ended.

During the 1950s and '60s, short articles—maybe a couple of column inches—would appear in the back pages of newspapers, with headlines like "Weather Recon Plane Reported Missing." Air Force bombers and Navy patrol planes not unlike the EP-3C downed in China recently regularly vanished off radarscopes or failed to make their radio checks. Burrows cites reports from living Russian servicemen who say they saw survivors pulled from the water and U.S. crew members in Soviet prisons.

Burrows recounts that President Dwight Eisenhower desperately wanted aerial surveillance but was tormented by the knowledge of how badly the flights could end. Most of the missions were sorely needed to map the defense radar system of the Soviet homeland; without that information, the Strategic Air Command might well have been essentially a kamikaze outfit. Most of these surveillance missions were flown without incident, but scores were settled by shooting down U.S. ferreting missions, and the fates of these missions didn't seem affected by how airplanes were marked, whether the crews wore uniforms, or whether the flight was legally in international airspace.



One supposes that it can't be said too often that these crew members regularly flew into danger, did it knowingly, and paid, in many cases, the ultimate sacrifice—well, it turns out that yes, it can be said too often. Some of the author's expressions of passion for the human toll of this silent war are a little repetitious. But the accounts of how agencies of the U.S. government performed so secretively during the cold war period and even afterward, when Russia opened its doors, should be shouted from the hilltops, perhaps hourly. At this time in our nation's history, Burrows's account is chilling.
—George C. Larson is the editor of Air & Space/Smithsonian.

CALENDAR

December 1
Aviation Photography and Art Show. Items for sale include framed photographs, hand-painted warbird nose-art panels, warbird notecards, refrigerator magnets, and hand-painted T-shirts. Planes of Fame Air Museum, Chino, CA, (909) 597-3722.

Introduction to Aerobatics Program and Fly-In Pancake Breakfast. Sponsored by Experimental Aircraft Association Chapter 690. Sport Aviation Center, Briscoe Field, Lawrenceville, GA, (770) 613-9501.

December 7
American Airpower Heritage Museum and Confederate Air Force Holiday Open House. Confederate Air Force Headquarters, Midland International Airport, Midland, TX, (915) 563-1000.

December 10
Prairie Aviation Museum Christmas Party. Central Illinois Regional Airport, Bloomington, IL, (309) 663-7632.

December 15
Wright Brothers Celebration. Explore the beginnings of flight with hands-on activities and a day of aviation-theme cinema. Virginia Aviation Museum, Richmond International Airport, (804) 236-3622.

January 12 & 13
Air Force Association Air Fair 2002. Tuskegee airmen, biplane and helicopter rides, vintage military vehicles, static displays of World War II, and antique and classic aircraft. Benefits Broward County Civil Air Patrol and U.S. Air Force ROTC junior cadets. Pompano Beach Air Park, Pompano Beach, FL, (954) 746-7759.

January 20
Open Cockpit Sunday. Approximately 12 aircraft will be open for visitors, including helicopters, a DC-3 airliner, and World War II and modern fighters. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (860) 623-3305.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *750 9th St. NW, 7th Floor, Washington, DC 20560. Events will be listed as space allows.*

CREDITS

Pushback: Newark Airport, 8:45 a.m. The author is a pilot for a major airline based in New York.

When Pigs Fly. Frequent contributor Richard Sassaman lives in Maine. He would like to see the Missouri barbecue team get their hands on a Concorde.

Young Turks. Having moved on from a series of grown-up jobs, Roger A. Mola now writes about aviation for the International Council of Airshows, *Aviation International News*, and *Air & Space/Smithsonian.*

Photographer Luigino Caliaro has been contributing to international aviation magazines since 1992.

Special Report: Aftermath. Lester A. Reingold, who worked at the National Transportation Safety Board for seven years, writes frequently about aviation. His last article in *Air & Space* was "New Approach" (Feb./Mar. 2000).

Ready, Set, Flap! Graham Chandler, a graduate of the U.S. Naval Test Pilot School, is a freelance writer whose work has appeared in several national and international magazines.

Aviation photographer Phil Schofield has recently been photographing subjects on the fringe of flight, like paragliding and kite-surfing.

How Things Work: Cabin Pressure. George C. Larson is the editor of *Air & Space*. When able, he flies light airplanes at low altitude.

Science Floats. T.A.Heppenheimer writes magazine articles and books about science and technology; his most recent work is a history of the space shuttle for NASA.

Contributing editor Chad Slattery has been photographing for the magazine since 1986. His images are on the Web at *aeropix.com*.

Restoration: The Bat. Jim Sweeney is a freelance writer based in Alexandria, Virginia.

The Front Office. Eric Long and Mark Avino are Smithsonian Institution staff photographers.

The Rocket Ships. Cape Canaveral-based Dan Kovalchik (*rangerat@digital.net*) works for Boeing's Delta launch operations. He also circled the globe aboard the USNS *Vanguard*, an experience that inspired his light-hearted memoir *Range Rats at Sea* (iUniverse, Inc., 2001).

Air Combat U. Robert A. Hanson is a freelance writer who lives in Olathe, Kansas. A retired U.S. Air Force lieutenant colonel, he flew 122 combat missions in Vietnam in the F-4E and was awarded both the silver and bronze stars.

Further reading: *The Mind of War: John Boyd and American Security*, Grant T. Hammond, Smithsonian Institution Press, 2001.

Check Six: A Fighter Pilot Looks Back, Major General (ret.) F.C. "Boots" Blesse, Champlin Fighter Museum Press, 1987.

FORECAST


CHAD SLATTERY

An F-111 in the Royal Australian Air Force.

Australian Aardvarks

A species with long legs and a nasty bite.

Operation Skyshield

Every news program after September 11 mistakenly reported that the grounding of U.S. airliners was unprecedented. Here's the true story of a cold war mission that swept the skies clean of all but combat aircraft rehearsing for the big one.

Sky Marshals

The passenger sitting beside you on your next flight.could be packing heat. How well are these gunslingers trained?

Building an Aerospace Library

Indispensable reference works, comprehensive histories, memoirs that soar: an *Air & Space/Smithsonian* guide to the books we couldn't live without.

ON THE WEB SITE

www.airspacemag.com

See the Turkish Stars in action in a video clip from *Turkish Stars: A Star is Born*, a film by Laurie K. Gilbert, which garnered the Best Cinematography award at the New York International Independent Film and Video Festival 2001.

Also, get the short tour of the National Air and Space Museum's new Explore the Universe exhibit. Images of selected artifacts are on the Web site.

The Hubble Space Telescope's flawless backup mirror.


ERIC LONG

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Finding the Wright Spot

When the time came to determine for posterity the exact spot where Orville Wright lifted off in 1903 in the first successful powered flying machine, there were two problems: time and terrain.

In 1912, William Tate, in whose home Wilbur stayed when he first visited Kitty Hawk, North Carolina, suggested that a suitable monument be erected at the site in question at Kill Devil Hill, which is actually about four miles south of Kitty Hawk. Eventually, in 1926, Representative Lindsay Warren of North Carolina introduced legislation to provide a proper memorial. After two years of haggling, Congress appropriated $277,688 for a 59-foot-high granite pylon to sit atop Kill Devil Hill, one of several mounds overlooking the flat stretch of sand where the flight took place.

But if Kill Devil Hill was still evident in 1928, not much else looked the same as it had 25 years earlier, thanks to the ever-shifting dunes, and planners couldn't build a monument without knowing exactly where the *Flyer* first rose into the wind on the morning of December 17, 1903. To resolve that issue, Tate once again stepped forward, this time representing the National Aeronautic Association, which wanted to mark the exact point of liftoff for the upcoming 25th anniversary.

COURTESY OF THE WRIGHT NATIONAL MEMORIAL

On November 4, 1928, Tate got together at Kill Devil Hill with three of the four men who had witnessed the flight and were still alive: Adam Etheridge, William Dough, and John Moore (the fourth, John Daniels, couldn't come that day, and neither could Orville Wright). In 1903, both Etheridge and Dough were working at the nearby Kill Devil Life Saving Station, and had been summoned (along with Daniels, another member of the station) to help the Wrights move their machine from the small wood building where they stored it to a nearby expanse of sand.

The men remembered that the Wrights had laid down a 60-foot wooden track on the sand from which to launch the *Flyer*. In Orville's account of the first flight, he wrote, "We laid the track on a smooth stretch of ground about 100 feet north of the…building."

By 1928, the storage building was long gone, but the men were able to identify the location of its corners. Working from that position, they used a compass to estimate the path of the track, and finally agreed on where the track neared its end and the *Flyer* became airborne. They marked the spot with a copper pipe and signed a statement: "We individually and collectively state without the least mental reservation that the spot we located is as near correct as it is humanly possible to be with the data in hand…after a lapse of twenty-five years."

On December 17, 1928, NAA marked the spot with a six-foot-high stone and a bronze tablet. It's one of the markers you see today when you visit the Wright Brothers National Memorial.

—*Stuart Nixon*

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LOGBOOK

Awards

The United States Air Force Academy was presented with the 2001 Cliff Henderson Award for Achievement for motivating and preparing young people for positions of leadership in the nation's defense community.

The Elder Statesman of Aviation Award was established in 1954 to honor citizens who over a period of years have made contributions of significant value to aeronautics. The 2001 recipients are: Arthur E. Abney, for contributions to general aviation safety programs; Robert A. Champine, a NACA and NASA test pilot; Jerrie Cobb, NASA's first female astronaut candidate and 40-year humanitarian pilot in the Amazon jungle; R. Richard Heppe, a Lockheed engineer and manager for 40 years; Raymond J. Johnson, for contributions to youth-oriented aviation activities and aerospace education programs; Elinor Smith, for a lifetime of aviation record-setting, flight testing, and stunt flying; and Albert L. Ueltschi, the founder of Flight Safety International.

Captain Jodi A. Neff received the 2001 Katherine and Marjorie Stinson Award for Achievement for service as a C-5 pilot and instructor with Air Force Special Operations.

The crew members of AIREVAC 10E1/10E2, 75th Airlift Squadron, and 86th Aeromedical Evacuation Squadron won the 2000 Clarence M. Mackay Trophy for their evacuation of victims of the attack on the USS *Cole*.

Neil Armstrong was awarded the 2001 Wright Brothers Memorial Trophy for lifetime achievement as a naval aviator, test pilot, astronaut, educator, business leader, and engineer. The award will be presented at a dinner on December 14, 2001, in Washington, D.C.